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A study on helminths and helminthiases in bison, *Bison bonasus* (L.)
in Poland

Badania nad robakami pasożytniczymi i robaczycami żubra,
Bison bonasus (L.) w Polsce

Many pages of the history of Poland deal with the fate of the bison showing the tremendous work of entire generations and the care given to the task to preserve this species. Disregarding several historic crashes in result of which the extinction of the bison seemed unavoidable, it has nevertheless survived and there are 130 head of this animal in Poland now, i. e. half the total number of *Bison bonasus* (L.) in the whole world. This number being quite a significant one in the case of the bison, still it does not vouch for the preserving of this species about to extinct. This anxiety had been particularly drastically felt during the 1953/54 foot-and-mouth disease epizootic when 36 bisons fell in a few months' time. That is why particularly much attention is being given to the reasonable reservation breeding of the bison and to giving it the most favorable environmental and food conditions as well as to preventing diseases of the bison.

The lack, in the Polish literature, of publications on the most frequent bison diseases, the parasitic invasions, induced the Department of Parasitology and Parasitic Diseases of the Agricultural College of Warszawa to undertake the present investigations with the aim to fill up at least a part of that gap.

The object of the present work was suggested to me by Prof. Witold Stefański, whom I think it my pleasant duty heartily to thank here for the much valuable advice and guidance I have received when performing the task assigned to me.

To Mrs. Danuta Tarczyńska I am indebted for preparing in ink the drawings included to this work.

The literature on the bison parasites and the invasive diseases caused by them is extremely poor and is represented only by a few studies dealing with the subject. The monography by Wróblewski 1927 is amongst the earliest works giving somewhat more precise data on the parasites of the bison. The author mentioned was carrying out his investigations during the period 1906 — 1918 in the Białowieża forest wilderness, his aim

being to give a possibly thorough study of the problems that might bear on the extinction of *Bison bonasus* (L.); consequently, he gave some consideration to the invasive diseases too. However, the parasitologic aspects of the problems studied were considered by the author incidentally only and the work therefore could solely contribute to an incomplete knowledge of the bison's parasites disregarding the tremendous quantity of the material dissected (81 animals). Neither were sufficient the investigations carried out by Wetzell et Enigk 1936, 1937 and by Bohn 1937 who founded their study on an insignificant number of coproscopic examinations of faeces of bisons from the zoological gardens in Germany. The first work giving somehow wider information on the problem is the study by Koffman 1942 who founded his research work on the material collected during the dissections of 13 bisons fallen for various reasons in Sweden from 1939 to 1941. Finally, the last original item in the list is represented by the Belaeva's work (1957; 1959) who studied the helminthic fauna of the mammals in the Białowieża reservation belonging to the USSR.

Part I. Helminthofauna of the bison

Material and methods

The material utilized for the present study was collected by means of helminthologic dissections of 25 *Bison bonasus* (L.) specimens fallen or shot. The animals fell for various reasons (as may be seen from Table I) which doubtlessly had told to a certain extent on the helminthologic picture. The highest proportion of the animals fallen was caused by foot-and-mouth disease or its after-effects. The most frequently noted foot-and-mouth disease after-effect was, in the animals dissected, the catarrhal purulent pneumonia which affected wide portions of the lung tissue in most cases. No parasitic worms were ever found in lungs affected by the inflammatory process of that extent. Also, acute gastric or intestinal inflammations used to result in the animals getting free from the gastro-intestinal worms (e.g. the bison „Poziomka” in the Warszawa Zoo). As to the remaining causes of death, no relationship was ever noted between the latter and the helminthologic picture — see Table I.

As a rule, all of the bisons were examined by the methods of complete helminthologic dissection except for the brains and the cranial sinuses, which would be accessible only after the destruction of the skull representing valuable scientific material, and for the pancreas autolysis of which could not be prevented in most cases. Thus, the following organs and tissues alone were examined: 1) bursa conjunctiva of the eye, 2) subcutaneous tissue, 3) abdominal cavity, 4) pectoral cavity, 5) intestine, 6) liver, 7) spleen, 8) urinary system — kidneys and bladder, 9) omentum, 10) mesentery, 11) heart, 12) respiratory system.

The routine methods for helminthologic dissections were subject to numerous modifications owing to the specific local conditions and to the dimensions of the particular organs of the bison. First the outside integument and the natural openings were inspected, then the animal was skinned and during this operation the subcutaneous tissue was being inspected. Next, the abdominal and pectoral cavities were opened and inspected. The intestinal tract was isolated and divided

into following sections: the oesophagus, the forestomachs, the abomasus, the small and the large intestines. Each of these sections was successively placed into special dissectional flat dishes filled with water, and cut with forceps; then the mucosa was scraped off and the whole contents of the particular section decanted until clear rinsing water was obtained. The proceeding was somewhat different only with the fore-stomachs. Because of the tremendous volume of the digesta contents in the fore-stomachs (up to 60 kg.), the bulk of it used to be removed following dissection and only that part of it as directly adhered to the mucosa was examined. Cold water from natural water bodies or from wells was utilized for decantation. The only exceptions were the dissections carried out in winter when the water had to be heated on a bonfire before utilization owing to the low temperature which fell down to -17°C on some occasions. The digesta were inspected on the spot after being rinsed for several times, and all parasites as were noticed were collected. Then, the digesta were poured into jars with some alcohol or 2 per cent. formalin solution added. The material obtained was now brought into laboratory where it was directly inspected in Petri dishes through a strong binocular magnification. The classical methods for disintegrating the liver with the subsequent decantation had to be given up due to the size of the organ. The surface of the liver was carefully inspected; following this as many biliary ducts as feasible were dissected and all of the parasites as were noticed were collected. Next, the contents were scraped off the open biliary ducts by means of a lancet and put into a glass recipient with water. After rinsing *Dicrocoelium dendriticum* were confirmed on several occasions. The dissection of the lungs was carried out in a similar method: cutting open the larynx, trachea, bronchia and the bronchioli.

The parasitic material obtained during the dissection was fixed in 75 per cent. alcohol and ± 5 per cent. glycerol. The trematodes and the cestodes were stained with alum carmine and lactic acid carmine after Blachin while creosote was utilized for clearing the preparations. Prior to treatment of the nematodes material collected, the same was put into Petri dishes filled with 75 per cent. alcohol ± 5 per cent. glycerol. When closing up the dishes a fitted stick was inserted between the two parts thus providing for a gradual evaporation of the alcohol which lasted for 2 or 3 months. After this, the already cleared nematodes remained in pure glycerol. The nematodes thus cleared were utilized for mounting numerous non permanent preparations. The required position of the specimen examined or the isolation of the particular morphotic elements was obtained by means of the appropriate manipulating with preparation needles (prepared of entomological needles) and with capillary tubes of glass. Also the ophtalmologist's lancets, razor blade chips and a micromanipulator designed by the present author himself were utilized for preparing the nematodes.

The preparing of some particular morphotic elements, e.g. the genital spiculae and the additory organ, is exceptionally toilsome and very often ends in damaging those elements. That is why, the NaOH maceration method was utilized. This method has been recommended by many authors; however, it had soon to be given up due to the soda base diluting the very tender structures of the genital spiculae. A series of experiments were carried out with the aim to improve the methods utilized so far. Finally a combined Foure-Berlese mixture, widely utilized in arachnoentomology, was applied. This mixture, gradually clearing the tissues, enabled the present author to trace back even the most tender structures. All of the tissues became absolutely cleared, the genital spiculae excepted, in 2 or 3 hours time (depending on the size of the nematode). Only the material which had been transferred into glycerol was immersed in this mixture, or the fresh one.

In studying the structure of the nematodes very useful were the running microphotographs obtained by casting onto sensitive paper of images by the Zeiss' Mirror Apparatus. A photographic plate, 9×12 cm., was utilized instead of the photographic sensitive paper to obtain a negative (permitting any desired enlargement) in cases when a more considerable degree of magnification of the image was required.

The parasitic material utilized in the present study was collected during the dissections of 25 bisons from various reservations and zoological gardens;

T a b
The bisons examined

No.	Name of bison	No. of pedigree register	Sex	Date of birth	Date and place of death	Date of dissection
1	Pułań	899	♂	22.V.1953	27.VI.1954 - Niepołomice	29.VI.1954
2	Pukajka	868	♀	25.VII.1952	28.V.1954 - Niepołomice	30.V.1954
3	Pustybór	905	♂	3.VII.1953	20.V.1954 - Niepołomice	21.V.1954
4	Pustak	787	♂	2.VI.1950	12.III.1954 - Gorce	13.III.1954
5	Pleśnienka	857	♀	15.V.1942	4.I.1954 - Pszczyna	5.I.1954
6	Pugorka	793	♀	20.VIII.1950	15.V.1952 - Gorce	17.V.1952
7	Pura	627	♀	17.IX.1943	2.V.1954 - Niepołomice	3.V.1954
8	Purchawka	714	♀	20.V.1947	1.V.1954 - Niepołomice	3.V.1954
9	Plusia	796	♀	24.IX.1950	19.I.1954 - Pszczyna	21.I.1954
10	Pułkownik	864	♂	8.VII.1952	23.V.1954 - Niepołomice	23.V.1954
11	Puszcza	673	♀	14.IV.1945	23.IV.1954 - Niepołomice	23.IV.1954
12	Pustelnik	694	♂	6.V.1946	27.IX.1954 - Płock - ZOO	27.IX.1954
13	Plebanka	768	♀	3.VIII.1949	28.II.1954 - Niepołomice	28.II.1954
14	Purata	943	♀	10.IX.1954	20.II.1956 - Niepołomice	24.II.1956
15	Punkt	597	♂	21.V.1942	11.XII.1952 - Pszczyna	11.XII.1952
16	Pukar	767	♂	30.VII.1949	31.VII.1950 - Gorce	2.VIII.1950
17	Pluvius	546	♂	15.IX.1940	20.XII.1957 - Białowieża	20.XII.1957
18	Poganin	716	♂	4.VI.1947	20.VIII.1956 - Białowieża	25.VIII.1956
19	Poziomka	674	♀	6.V.1954	22.I.1957 - Warszawa-ZOO	22.I.1957
20	Plato	575	♂	1.VI.1941	5.X.1958 - Białowieża	5.I.1958
21	Plater	824	♂	28.VII.1951	16.X.1958 - Warszawa-ZOO	16.X.1958
22	Burnus		♂	20.IX.1957	25.X.1958 - Borki	26.X.1958
23	Purkuł	625	♂	15.V.1943	4.I.1946 - Białowieża	5.I.1946
24	Purena		♀	5.XI.1958	27.I.1959 - Niepołomice	30.I.1959
25	Faun		♂	V.1945	28.IV.1960 - Poznań - ZOO	29.IV.1960

1 e I

- General data

Cause of death	Parasites found
Complications after aphtae epizooticae	D.viviparus
Complications after aphtae epizooticae - insufficiency of heart muscle	H.contortus, O.ostertagi, N.helvetianus, C.oncophora, C.mcmasteri, Oe.radiatum, T.gulosa, T.skrjabini, S.labiato-papillosa, C.bilobata
Complications after aphtae epizooticae - bronchopneumonia	Oe.radiatum, H.contortus, N.helvetianus, C.oncophora, C.mcmasteri, T.ovis
Complications after aphtae epizooticae	F.hepatica, Oe.radiatum, H.contortus, D.viviparus
Complications after aphtae epizooticae - suppurative bronchopneumonia	M.benedeni, Oe.radiatum, H.contortus, C.oncophora, T.gulosa, T.skrjabini
Complications after aphtae epizooticae	T.ovis
Complications after aphtae epizooticae - insufficiency of heart muscle	Oe.radiatum, O.ostertagi, C.oncophora, C.mcmasteri, H.contortus, S.labiato-papillosa
Aphtae epizooticae	S.labiato-papillosa
Complications after aphtae epizooticae - bronchopneumonia	M.benedeni, Oe.radiatum, H.contortus, N.helvetianus
Complications after aphtae epizooticae	C.oncophora, H.contortus, N.helvetianus
Aphtae epizooticae	S.labiato-papillosa
	F.hepatica, H.contortus, D.viviparus, T.skrjabini
Aphtae epizooticae	Oe.radiatum, H.contortus, T.ovis
Intestinal hernia - perforation of abdomen coat, death after operation	H.contortus, C.oncophora
	M.benedeni
	T.ovis
Shot	D.dendriticum, P.cervi, T.gulosa, T.skrjabini
Dead during unproperty arranged transport	P.cervi
Gastroenteritis acuta	
Narcotized	F.hepatica, D.dendriticum, T.axei, O.ostertagi, D.viviparus
	T.axei, O.ostertagi, B.trigonocephalum
Shot	P.cervi, Moniezia sp., Oe.radiatum, T.axei, O.ostertagi, S.spiculoptera, C.oncophora, H.contortus
Enteritis catarrhalis chronica	F.hepatica, P.cervi, T.axei, O.ostertagi, O.lyrata, H.contortus, D.viviparus, C.bilobata, D.dendriticum
Shot	D.dendriticum, P.cervi, T.axei, O.ostertagi, H.contortus, C.oncophora, C.bilobata

the material consisted of 3 species of *Trematoda*, 2 species of *Cestoda* and 16 species of *Nematoda* — see Table I.

Summing up, the present author has discovered 21 species of worms parasitizing *Bison bonasus* (L.) in Poland. Four of them, the parasitic *Nematoda*: *Thelazia gulosa*, *Thelazia skrjabini*, *Spiculopteria spiculoptera* and *Capillaria bilobata* have been confirmed for the first time in Poland. The remaining species belonged to the worms parasitizing the domestic ruminants in Poland; most of these species were described by Żarnowski 1949. As the descriptions by Żarnowski do correspond to the present author's own observations, no descriptions nor pictures of these species of *Nematoda* will be repeated in the present paper. Solely their specific names have been listed, and the hosts as well. The same applies to the common species of *Cestoda* and *Trematoda*, precise descriptions of which may be found in almost every textbook on parasitology.

The helminths stated in the bison

TREMATODA

Fasciolidae Railliet 1895

Fasciola hepatica Linné 1758

Definite hosts: *Bovidae*, *Cervidae*, *Camelidae*, *Suidae* and other mammals.

Intermediate hosts: in Europe *Galba truncatula* (O. F. Müller).

Location: hepar.

Geographical distribution: cosmopolitan.

Dicrocoeliidae Odhner 1910

Dicrocoelium dendriticum (Rudolphi 1819) Looss 1899

Definite hosts: *Bovidae*, *Cervidae*, *Camelidae*, *Suidae*, *Canidae*, *Ursidae*, *Equidae*, *Leporidae* and other mammals.

Intermediate hosts: *Helicidae*, *Zonitidae*, *Enidae*, *Vertiginidae*, *Cochlicopidae*.

Supplementary hosts: *Formica* (*Serviformica*) *fusca* L., *F. (S.) rufibarbis* Fabr., *F. (S.) gagates* Latr.

Location: hepar.

Geographical distribution: cosmopolitan.

Paramphistomatidae Fischöder 1901

Paramphistomum cervi (s. l.) (Zeder 1790)

Definite hosts: *Bovidae*, *Cervidae*.

Intermediate hosts: *Planorbidae*.

Location: rumen.

Geographical distribution: cosmopolitan.

CESTODA

Anoplocephalidae Cholodkovsky 1902

Moniezia benedeni (Moniez 1879) Blanchard 1891

Definite hosts: *Bovidae*, *Cervidae*, *Camelidae*.

Intermediate hosts: *Galumna obivous* Berl., *Scheloribates laevigatus* (Koch.), *Sch. latipes* Koch., *Adoristes ovatus* Koch.

Location: small intestine.

Geographical distribution: cosmopolitan.

Moniezia (s. l.) sp.

During the dissection of a 2 year old bison, a fragment of a tapeworm (a 5 cm. long portion of the strobila consisting of sexual proglottides only) belonging to the genus *Moniezia* Blanchard 1891 was found in the small intestine. The specimen found differed in structure from other species belonging to the same genus known to the present author from literature.

Length of proglottis 1.18 mm., width 1.92 mm. Double genital system. Genital sinuses disposed at the edges of proglottis, 0.326 mm. off the front edge. The region of the genital sinus exhibits a scarcely visible swelling. Large ovaries, ovoid in shape, measuring 0.798 mm. in length and 0.467 mm.

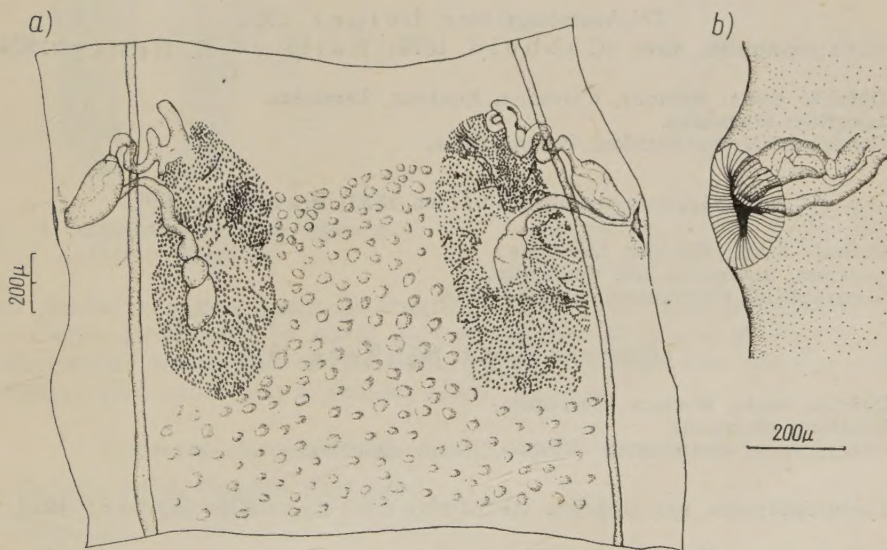


Fig. 1. *Moniezia* (s. l.) sp.? a — the sexual proglottide, b — the region of the genital sinus

in width, exhibiting fine granular structure are situated on both sides of the proglottis. The bursa copulatrix is 0.270 mm. long, its maximum width — 0.032 mm. Receptaculum seminis is 0.304 mm. in length and 0.047 in width.

The male genital system consists of numerous testicular vesicles 0.059 mm. in diameter, situated in the middle part of the proglottis between the longitudinal excretory ducts. The bursa cirri is ovoid in shape, 0.198 mm. in length and 0.087 mm. in width. The cirrus is not armed. A short and relatively thick ductus seminalis enters the bursa cirri forming a few loops at the level of the front edge of the ovary.

NEMATODA

Ancylostomatidae (Looss 1905) Lane 1917*Bunostomum trionocephalum* (Rudolphi 1808) Railliet 1902Definite hosts: *Bovidae*.

Location: small intestine.

Geographical distribution: cosmopolitan.

Trichonematidae Witenberg 1925*Oesophagostomum (Basicola) radiatum* (Rudolphi 1803) Railliet 1898Definite hosts: *Bovidae*, *Cervidae*.

Location: large intestine and caecum.

Geographical distribution: cosmopolitan.

Trichostrongylidae Leiper 1912*Trichostrongylus axei* (Cobbold 1879) Railliet et Henry 1909Definite hosts: *Bovidae*, *Cervidae*, *Equidae*, *Tamidae*.

Location: abomasus.

Geographical distribution: cosmopolitan.

Ostertagia ostertagi (Stiles 1892) Ransom 1907Definite hosts: *Bovidae*, *Cervidae*.

Location: abomasus and duodenum.

Geographical distribution: cosmopolitan.

Ostertagia lyrata Sjöberg 1926Definite hosts: *Bovidae*, *Cervidae*.

Location: abomasus.

Geographical distribution: Europe, North America.

Spiculopteragia spiculoptera (Guschanskaja 1931) Orloff 1933Definite hosts: *Bovidae*, *Cervidae*.

Location: abomasus.

Geographical distribution: Europe, Australia, Asia. In Poland recorded for the first time.

The male. Body length 5.3 mm., maximum width 0.088 mm. in the region of the bursa copulatrix. The bursa copulatrix structure, typical of the genus *Spiculopteragia*, consists of two well formed lateral lobes and of a dorsal one. The ventro-ventral ribs are thin and straight while the latero-ventral ones are considerably thicker and bent. Both of the ventral ribs meet with their distal ends at the edge of the bursa copulatrix. The lateral ribs are relatively thin. The fronto-lateral and the medio-lateral ribs run parallelly to each other in their entire length while the postero-lateral one (the longest one in the whole set of ribs) runs separately. The thick and short externo-dorsal ribs do not reach the edge of the bursa copulatrix. The short dorsal rib is divided into two branches which then bifurcate again.

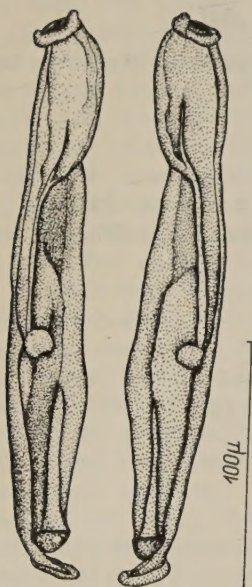


Fig. 2. *Ostertagia lyrata* Sjöberg
1926 — spiculae

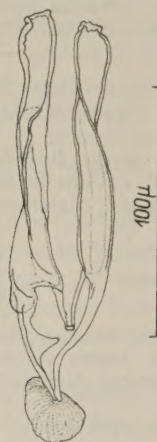


Fig. 3. *Spiculoptera spiculoptera*
(Guschanskaja 1931) Orloff 1933 —
spiculae

The genital spiculae equal in length — 0.161 mm., are asymmetric with a complex structure. The distal part of the left spicula is divided to form 2 appendices while that of the right one forms three. The spiculae end in cuticular alae exhibiting a distinct radial striation.

Cooperia oncophora (Railliet 1898) Ransom 1907

Definite hosts: *Bovidae*, *Camelidae*.

Location: small intestine and abomasus.

Geographical distribution: cosmopolitan.

Cooperia mcmasteri Gordon 1932

Definite hosts: *Bovidae*.

Location: small intestine and abomasus.

Geographical distribution: Australia, Europe.

Nematodirus helvetianus May 1920

Definite hosts: *Bovidae*, *Camelidae*, *Cervidae*.

Location: small intestine and abomasus.

Geographical distribution: cosmopolitan.

Haemonchus contortus (Rudolphi 1803) Cobbold 1898

Definite hosts: *Bovidae*, *Cervidae*, *Camelidae*, *Ursidae*, *Tamidae*, *Suidae* and other mammals.

Location: abomasus and small intestine.

Geographical distribution: cosmopolitan.

Dictyocaulidae Skrjabin 1941*Dictyocaulus viviparus* (Bloch 1782) Railliet et Henry 1907Definite hosts: *Bovidae*, *Cervidae*.

Location: bronchi and trachea.

Geographical distribution: cosmopolitan.

Setariidae Skrjabin et Schikhobalova 1945*Setaria labiato-papillosa* (Alessandrini 1838)Definite hosts: *Bovidae*, *Cervidae*.

Location: cavum abdominis.

Geographical distribution: cosmopolitan.

Thelaziidae Skrjabin 1915*Thelazia skrjabini* Erschow 1928Hosts: *Bos taurus*, *Bison bonasus*.

Location: bursa conjunctiva of the eye.

Geographical distribution: Europe, Asia.

Thin filiform body, equally wide in the whole length with ends rounded up and somewhat narrower. Cuticle exhibits a scarcely visible striation. Six papillae situated on the surface of the rounded up head: four central and two

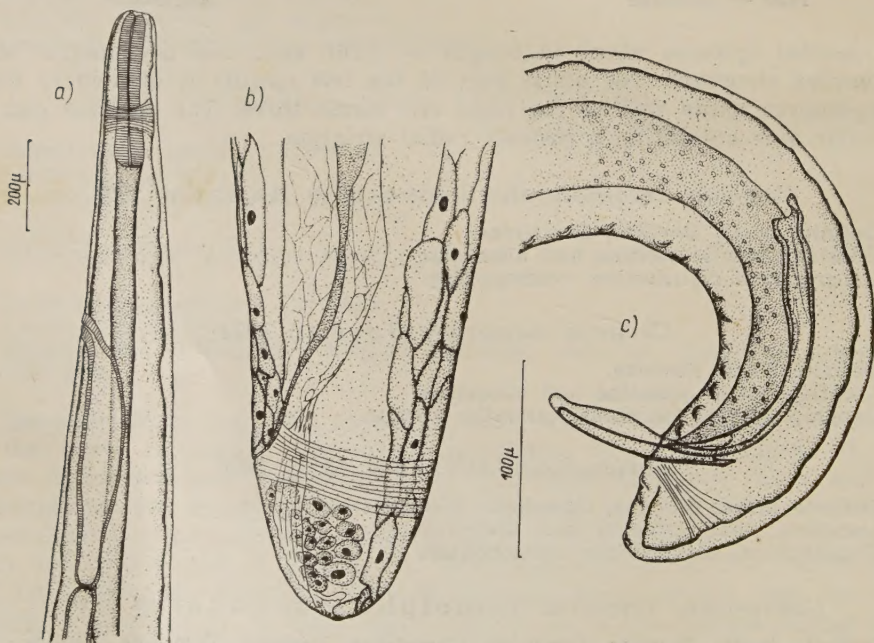


Fig. 4. *Thelazia skrjabini* Erschow 1928. a — fore end of the female, b — hind end of the female, c — hind end of the male

lateral ones. The mouth opening, situated terminally, is devoid of lips and leads into a small rudimental mouth pouch resembling a cut off cone — narrow at the opening and gradually widening inside. Its maximum width — 0.025 mm. and depth — 0.008 mm. The cylindrical pharynx is 0.287 — 0.355 mm. in length and 0.040 — 0.078 mm. in width. A distinctly visible neural ring is situated at a distance of 0.152 to 0.210 mm. from the fore end. The intestine, even in width, may be seen through the tissues of the parasite in the entire length of the latter.

The male. Body length — 5.2 to 8 mm. with maximum width — 0.195 to 0.213 mm. The rudimental mouth pouch leads into a cylindrical pharynx, 0.287 to 0.323 mm. in length and 0.040 to 0.048 mm. in width. The neural ring is distant 0.181 to 0.198 mm. from the fore end.

The hind end of the body, ventrally bent, is armed with two genital spiculae of equal width — 0.007 to 0.009 mm., but differing in length, the right one being 0.096 to 0.119 mm. and the left one — 0.132 to 0.169 mm. long. The number of the precloacal papillae varies from 15 to 26 pairs. They run along one line and occur most densely near the cloaca. There are three pairs of postcloacal papillae.

The female. Body length — 14.6 to 16 mm. with maximum width — 0.194 to 0.275 mm. The pharynx length — 0.290 to 0.355 mm., its width — 0.063 to 0.078 mm. The neural ring is distant 0.152 to 0.210 mm. from the fore end. The sexual opening is in the fore part of the body, 0.553 to 0.642 mm. from the fore end. The anal opening is situated 0.091 to 0.097 mm. from the tail end.

Thelazia gulosa (Railliet et Henry 1910)

Hosts: *Bos taurus*, *Bison bonasus*.

Location: bursa conjunctiva of the eye.

Geographical distribution: Europe and Asia.

The rather thick nematodes, almost transparent while alive; the fore end is markedly rounded up and the caudal one is pointed. The body is covered with cuticle in which fine transversal striation may be seen. The mouth opening is devoid of lips and leads into a relatively large mouth pouch. The shape of the latter resembles a cone with the top cut off, the largest diameter of the cone lays at the level of the mouth opening. The mouth pouch goes over into an almost cylindrical pharynx, slightly distended at the point where it is going over into the intestine.

The male. Body length — 6 to 9.4 mm. with maximum width — 0.369 mm. Maximum diameter of mouth pouch — 0.025 to 0.034 mm., its depth ranging from 0.014 to 0.029 mm. Length of the cylindrical pharynx — 0.258 to 0.369 mm.; its width — 0.066 to 0.078 mm. The neural ring is situated 0.078 to 0.161 mm. from the fore end. The caudal end is bent ventrally. Width at the cloaca level — 0.094 to 0.110 mm. The hind end of body is provided with two genital spiculae, different in length. The short right one, slightly bent, is 0.140 to 0.149 mm. long and 0.011 to 0.022 mm. thick. The left spicula, considerably longer and thinner, is 0.735 to 0.850 mm. long and 0.005 to 0.008 mm. thick. The cuticle on the hind end of body is covered with small sexual papillae. Most of the latter are pre-cloacal papillae, 15 to 22 pairs in number. They

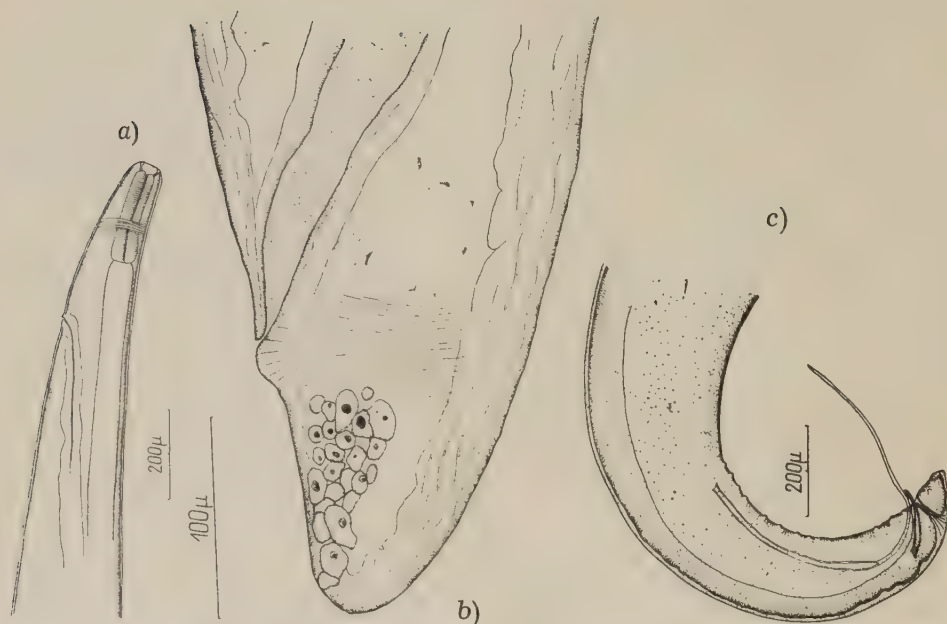


Fig. 5. *Thelazia gulosa* Railliet et Henry 1910. a — fore end of the female, b — hind end of the female, c — hind end of the male

occur most densely at the region of the cloaca. There are three pairs of post-cloacal papillae.

The female. Body length — 8 to 15 mm. with maximum width — 0.399 to 0.579 mm. The mouth pouch dimensions: maximum width — 0.044 to 0.056 mm., depth — 0.014 to 0.054 mm. Pharynx length — 0.323 to 0.411 mm., and width — 0.073 to 0.106 mm. The neural ring is situated at a distance of 0.152 to 0.239 mm. from the fore end. The sexual opening, in the front part of the body, is situated at a distance of 0.390 to 0.591 mm. from the fore end. The anal opening is situated 0.106 to 0.133 mm. off the caudal end.

Capillariidae Neveu-Lemaire 1936

Capillaria bilobata Bhalerao 1933

Syn.: *Capillaria bisonis* Koffman 1942; *C. megrelica* Rodonaja 1947.

Hosts: *Bos taurus*, *Bison bonasus*, *Capra hircus*.

Location: abomasus.

Geographical distribution: India, Sweden, Georgia (Caucasus), Poland.

Thin nematodes, white while alive, with gradually distending body width towards the caudal end. Smooth and rounded up fore end, 0.008 — 0.012 mm. in diameter. Mouth opening leading directly into a muscular pharynx, 0.382 to 0.488 mm. in length, then going over into a glandular pharynx. Presence of a glandular agglomeration, yellow-brown in colour, granular in structure, at the base of the pharynx end.

Table II
Measurements of 10 individuals of *Capillaria bilobata* males from bison

Measurements in microns	1	2	3	4	5	6	7	8	9	10
diameter of the head end	12	12	12	12	12	8	8	8	7	8
length of the spicule	219	216	210	202	213	203	195	196	196	200
width of the spicule	6	5	7	6	7	6	8	5	7	5
length of lateral alae	71	71	71	69	82	66	67	59	72	59
width of lateral alae	18	20	16	18	25	21	20	17	23	22
length of muscular part of oesophagus	470	473	483	386	464	473	440	428	488	409
length of whole oesophagus	7486	7400	7294	8026	7100	7400	7516	6588	7100	7559
maximum width of oesophageal part	59	60	60	66	59	60	59	59	56	66
maximum width of posterior part	73	73	73	73	69	73	72	63	71	76
length of the body	14618	14523	14327	15547	13949	14523	14090	13483	14458	14875
length of the posterior part	7131	7122	7032	7520	6849	7122	6574	6895	7358	7316

Table III
Measurements of 10 individuals of *Capillaria bilobata* females from bison

Measurements in microns	1	2	3	4	5	6	7	8	9	10
distance between vulva and oesophagus end	64	91	64	89	89	45	75	65	93	74
eggs dimensions	49 × 19	49 × 19	50 × 21	50 × 21	51 × 20	44 × 16	52 × 22	46 × 21	45 × 21	48 × 20
length of muscular part of oesophagus	383	452	458	420	439	439	448	427	461	428
length of whole oesophagus	8613	7529	7810	7396	7597	7300	7516	7544	8136	8136
length of posterior part of the body	12396	11929	10355	11751	11523	9813	11482	11538	12187	10513
length of the body	21010	19458	18165	19148	19121	17114	18998	19082	20324	18649
width of oesophageal part of the body	82	62	66	59	62	59	62	63	78	65
width of posterior part of the body	102	66	81	68	75	65	78	82	90	85
length of vulva	344	306	272	238	223	285	460	236	315	306

The male. Body length — 13.4 to 15.5 mm., of which 6.5 to 8 mm. make out the pharynx, and 6.5 to 7.5 mm. — the hind part, thus the ratio between the fore and hind parts being 1 : 1. Maximum width of fore part — 0.056 to 0.066 mm., that of hind part — 0.063 to 0.076 mm. Length of the unique genital spicula — 0.195 to 0.210 mm., its maximum width — 0.005 to 0.008 mm.; scarcely visible transverse striation. Spicula situated in a smooth sheath which can turn inside out. Hind end of body provided with delicate, trans-

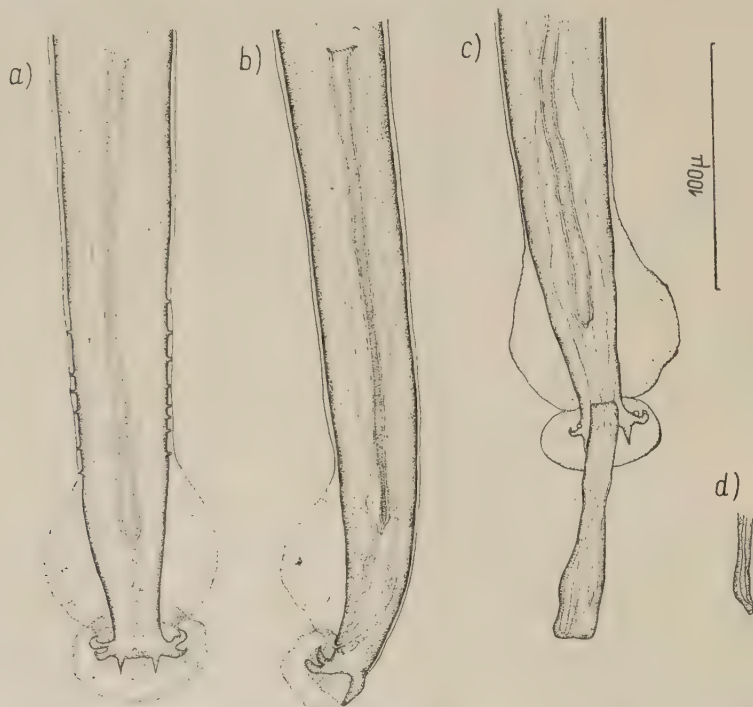


Fig. 6. *Capillaria bilobata* Bhalerao 1933 — male. a — the hind end, ventral, b — the hind end, lateral, c — the hind end with the spicula pouch, d — the hind part of the spicula, lateral

parent lateral alae, 0.059 to 0.082 in length, 0.016 to 0.025 mm. in width. Caudal end, shaped to form a sort of „copulation pouch”, is supported by four papillae (two lateral and two medial ones). Bifurcated lateral papillae tips; no bifurcation in the medial ones. A transparent cuticular lobe, measuring 0.049 to 0.017 mm., spreads around the above set of papillae exhibiting a zone of granular structure only in the next zone directly adjacent to the former — Table II.

The female. Body length — 17.1 to 21 mm. of which 7.3 to 8.6 mm. make out the pharyngeal part, 9.8 to 12.3 making out the hind part. The widest dimension of the pharyngeal part 0.059 to 0.082 mm., the hind part of it — 0.065 to 0.102 mm. The caudal part of body becomes gradually narrower with a rounded up end. Subterminally situated anal opening. The horse-

-shoe-shaped female sexual opening, partly covered with a cuticular lobe from below, is situated at a distance of 0.045 to 0.093 mm. from the end of the pharynx. Insignificant cuticular swellings may occur around the sexual opening, the former may vary in shape and number depending on

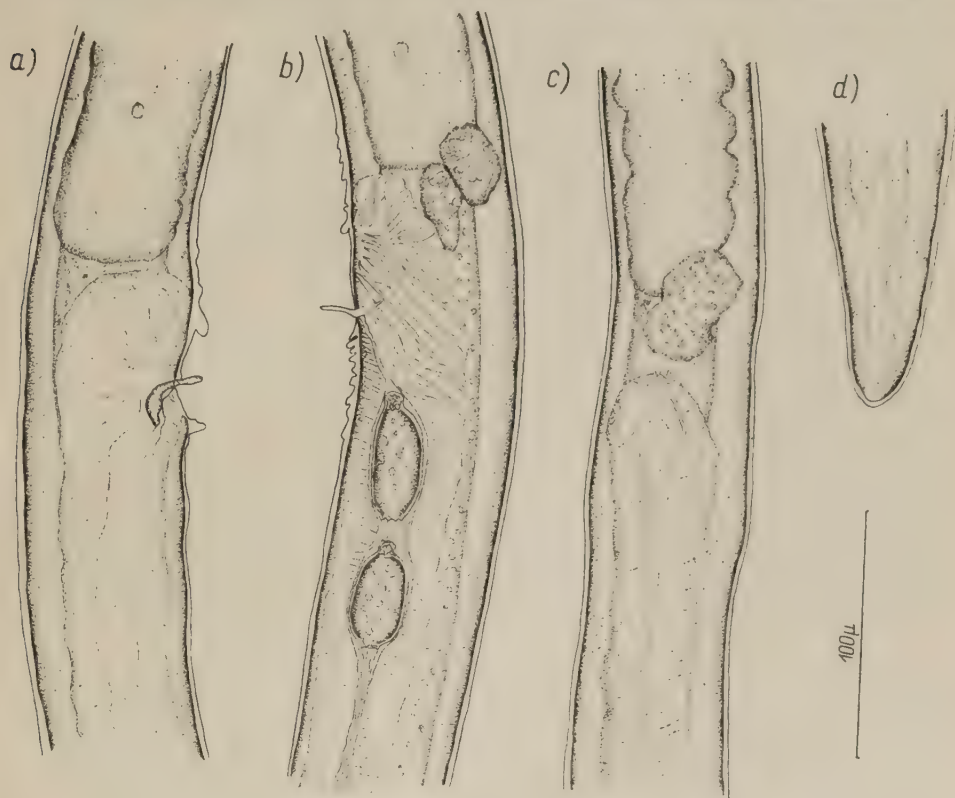


Fig. 7. *Capillaria bilobata* Bhalerao 1933 — female. a — the region of the genital opening, b — the region of the genital opening from above, c — the hind end

the individual specimen or may be absent at all. The well developed vagina, 0.223 to 0.460 mm. in length, exhibits strong muscular system especially in the proximity of the sexual opening. Lemon-shaped eggs measure 0.044 — 0.052 by 0.016 — 0.022 mm. — Table III.

Discussion. The nematodes found in *Bison bonasus* (L.) and belonging to genus *Capillaria* Zeder 1800 were classified within the species *Capillaria bilobata* Bhalerao 1933 following a close morphological study. In the literature available the present author has come across descriptions of two species of genus *Capillaria* resembling in their structure his own material from the bison. These were: *Capillaria bisonis* Koffman 1942, found in the *Bison bonasus* (L.) abomasus in Sweden, and *Capillaria megrellica* Rodonaja 1947 confirmed in the *Capra hircus* abomasus in Georgia

in the Caucasus. Both of these species were given rather insufficient description and biometric data by their authors. Besides, Koffman 1942 illustrated his description with indistinctive microphotographs only, while Rodonaja 1947 gave solely a drawing of the hind part of the male. On comparing the data concerning *Capillaria bisonis* and those concerning *Capillaria megrelica* on the one hand to the present author's own material and the description of *Capillaria bilobata* on the other, the present author has

T a b l e I V
Measurements of *Capillaria bilobata* after various authors

Measurements in microns	Drózdź	Bhalerao (1933)	Koffman (1942)	Rodonaja (1947)
M a l e :				
diameter of the head end	8-12	-	-	8.4
length of the spicule	195-219	190-240	200	200
width of the spicule	5-8	6.5-10	5	15
length of lateral alae	59-82	75	-	70
width of lateral alae	16-25	22	-	22
dimensions of "bursa copulatrix"	49 × 17	48 × 27	-	-
length of muscular part of the oesophagus	386-488	430-470	-	-
length of the whole oesophagus	6.5-8 mm	5.2-8 mm	6-7 mm	5 mm
length of the poste- rior part	6.5-7.6 mm	-	-	-
length of the body	13.4-15.5mm	10.1-16.5mm	11-14 mm	11.8mm
width of oesophageal part	56-66	40-55	40-60	58
width of posterior part	63-76	50-83	-	-
F e m a l e :				
distance between vulva and the oesophagus end	45-93	55-75	-	-
eggs dimensions	44-52 × 16-22	33-53 × 14-21	55 × 20	53-55 × 18-20
length of muscular part of oesophagus	382-461	-	-	-
length of whole oesophagus	7.3-8.6 mm	6.5-9.4 mm	7-8 mm	-
length of posterior part of the body	9.8-12.3mm	-	-	-
length of the body	17.1-21 mm	14-21.3mm	14-19 mm	18-20mm
width of oesophageal part	59-82	-	-	-
width of posterior part	65-102	72-85	50-75	90
length of vulva	223-460	235-254	-	-

concluded on the absence of any morphological or biometrical differences (see Table II—IV) that would justify the differentiation of these species. For this reason, the present author considers *Capillaria bisonis* Koffman 1942 and *Capillaria megrelica* Rodonaja 1947 as synonyms of *Capillaria bilobata* Bhalerao 1933 — see Table IV.

Trichocephalidae Baird 1852
Trichocephalus ovis Abildgaard 1795

Definite hosts: *Bovidae*, *Cervidae*, *Camelidae*, *Giraffidae*, *Hystriidae*.

Location: caecum and large intestine.

Geographical distribution: cosmopolitan.

Discussion of results

The comparison of the investigations carried out by Wetzel et Enigk 1936, Koffman 1942, Belaeva 1957, and by the present author himself shows that the widest range of parasitic worm species was established by the latter in *Bison bonasus* (L.) in Poland. This may be clearly seen from the Table V giving the parasite species found by the authors mentioned.

The bison parasites established so far mostly belong to the well known and common species occurring in both domestic and wild animals. The list of Koffman 1942 alone shows parasites specific exclusively of the bison only, namely the following five species: *Ostertagia gracilis* Koffman 1942, *Cooperia bisonis* Koffman 1942, *Nematodirus bisonis* Koffman 1942; *Dictyocaulus bisonis* Koffman 1942, *Capillaria bisonis* Koffman 1942. However, the descriptions of these species are not clear, the biometric data are insufficient and the accompanying illustrations consist solely of microphotographs, not always discernible. Therefore, it is very doubtful whether these really are different species. Taking into account descriptions of new species, Koffman may be assumed to have given insufficient attention to the publications concerning this parasitic group. Thus, when describing a new species of nematode belonging to genus *Cooperia*, he named it *Cooperia bisonis* Koffman 1942 disregarding of Cram who described nematode from the *Bison bison* abomasus under the same species name (*Cooperia bisonis* Cram 1925) as early as 1925.

There are striking errors in Koffman's descriptions of some species showing the author's ignorance of the particular taxonomic features of the parasitic group studied. Thus, in describing *Ostertagia gracilis* sp. nova, the author has maintained that the species was provided with a supplementary membrane of the copulation pouch supported by ribs, typical of the genus. However, the accompanying microphotograph showed a genital cone provided with telamon with structure characteristic of genus *Cooperia* Ransom 1907. The description of the ribs of the copulation pouch too, as well as the lacking additory organ are demonstrative of the species described belonging to genus *Cooperia*.

Taking into consideration the characteristic structure of the genital cone and the genital spiculae as well that of the copulation pouch, the present author considers *Ostertagia gracilis* Koffman 1942 synonymous with *Cooperia oncophora* (Railliet 1898) Ransom 1907. It can also be seen from the description of *Dictyocaulus bisonis* Koffman 1942 that it is synonymous with *Dict. viviparus* (Bloch 1782) to which fact already Dougherty 1946 has paid attention. And, finally, *Capillaria bisonis* Koffman 1942 is synonymous with *Capillaria bilobata* Bhalareo 1933 (see p. 70). The revision of the remaining two species described by Koffman is somewhat complicated owing to the insufficient description and the lack of illustrations.

Table V
List of parasites discovered in the bison (*Bison bonasus*)

No.	Name of parasite	Auer 1893-1894	Kulagin 1919	Wróblewski 1927	Wetzel, Enigk 1936	Bohn 1937 Ruchl. 1939 Zabłocki 1951	Koffman 1942	Bielajewa 1957-1959	Drózd
TREMATODA									
1	<i>Fasciola hepatica</i>	+	+	+	+		+		+
2	<i>Dicrocoelium dendriticum</i>		+	+			+		+
3	<i>Paramphistomum cervi</i>		+	+					+
CESTODA									
4	<i>Moniezia expansa</i>			+	sp.?				
5	<i>Moniezia benodeni</i>			+					+
6	<i>Moniezia</i> sp.								+
7	<i>Teenia hydatigena</i> larvae		+						
8	<i>Teenia multiceps</i> larvae					2. +			
NEMATODA									
9	<i>Strongyloides</i> sp.				+				
10	<i>Oesophagostomum venulosum</i>		+						
11	<i>Oesophagostomum radiatum</i>							+	+
12	<i>Bunostomum trigonocephalum</i>						+		+
13	<i>Trichostrongylus axei</i>				sp.?		+		+
14	<i>Trichostrongylus falcuatus</i>						+		
15	<i>Ostertagia ostertagi</i>				sp.?		+	+	+
16	<i>Ostertagia circumcincta</i>						+		
17	<i>Ostertagia lyrata</i>								+
18	<i>Spiculopteria spiculoptera</i>								+
19	<i>Cooperia oncophora</i>		+				"O. grac."	+	+
20	<i>Cooperia mcmasteri</i>								+
21	<i>Haemonchus contortus</i>		+	+			+	+	+
22	<i>Nematodirus helvetianus</i>							+	+
23	<i>Nematodirus filicollis</i>						+		
24	<i>Nematodirus spathiger</i>						+		
25	<i>Dictyocaulus viviparus</i>		+	+	+	B. +	"D.bis."	+	+
26	<i>Dictyocaulus filaria</i>			+					
27	<i>Müllerius capillaris</i>				+				
28	<i>Thelazia rhodesi</i>					R. +			
29	<i>Thelazia gulosa</i>								+
30	<i>Thelazia skrjabini</i>								+
31	<i>Setaria labiato-papillosa</i>			+					+
32	<i>Capillaria bilobata</i>						"C.bis."		+
33	<i>Gongylonema pulchrum</i>		+	+					
34	<i>Trichocephalus ovis</i>		+		sp.?		+	+	+

T a b l e VI
List of parasites found in bison sectioned

Name of parasite	Number of bison			Reservation
	examined	invaded	N of invasion	
<i>F.hepatica</i>	25	4	16	Gorce, Płock-ZOO, Białowieża
<i>D.dendriticum</i>	25	4	16	Białowieża, Poznań-ZOO
<i>P.cervi</i>	25	5	20	Białowieża, Borki, Poznań-ZOO
<i>M.benedeni</i>	25	3	12	Pszczyna
<i>Moniezia</i> sp.	25	1	4	Borki
<i>Oe.radiatum</i>	25	8	32	Borki, Gorce, Niepołomice, Pszczyna
<i>B.trigonocephalum</i>	25	1	4	Warszawa-ZOO
<i>T.axei</i>	25	5	20	Borki, Białowieża, Warszawa-ZOO, Poznań-ZOO
<i>O.ostertagi</i>	25	7	28	Borki, Białowieża, Warszawa-ZOO, Poznań-ZOO, Niepołomice
<i>O.lyrata</i>	25	1	4	Białowieża
<i>S.spiculoptera</i>	25	1	4	Borki
<i>C.oncophora</i>	25	8	32	Borki, Niepołomice, Pszczyna, Poznań-ZOO
<i>C.mcmasteri</i>	25	3	12	Niepołomice
<i>H.contortus</i>	25	13	52	Borki, Białowieża, Niepołomice, Gorce, Pszczyna, Płock-ZOO, Poznań-ZOO
<i>N.helvetianus</i>	25	4	16	Niepołomice, Pszczyna
<i>D.viviparus</i>	25	5	20	Białowieża, Gorce, Płock-ZOO, Niepołomice
<i>T.gulosa</i>	25	3	12	Białowieża, Niepołomice, Pszczyna
<i>T.skrjabini</i>	25	4	16	Białowieża, Niepołomice, Pszczyna, Płock-ZOO
<i>S.labiato-papillosa</i>	25	4	16	Niepołomice
<i>C.bilobata</i>	25	3	12	Białowieża, Niepołomice, Poznań-ZOO
<i>T.ovis</i>	25	4	16	Gorce, Niepołomice

At any rate there are no sufficiently motivated reasons to consider them as particular species to the present writer's opinion.

Out of the 21 species of parasitic worms confirmed by the present author in *Bison bonasus* (L.) in Poland, the following turned out to occur most frequently (see Table VI): *Fasciola hepatica*, *Dicrocoelium dendriticum*, *Paramphistomum cervi*, *Moniezia benedeni*, *Oesophagostomum radiatum*, *Trichostrongylus axei*, *Ostertagia ostertagi*, *Cooperia oncophora*, *Haemonchus contortus*, *Dictyocaulus viviparus*, *Cooperia mcmasteri*, *Thelazia gulosa*, *Thelazia skrjabini*, *Setaria labiato-papillosa*, *Trichocephalus ovis* and *Capillaria bilobata* while *Moniezia* sp., *Bunostomum trigonocephalum*, *Ostertagia lyrata* and *Spiculopteragia spiculoptera* occurred in isolated cases only. Thus, two

groups of parasites could be differentiated in the helminthic fauna of the bison in Poland: 1) parasites characteristic of the helminthic fauna of the bison, occurring often and, usually, in large invasions, 2) casual parasites.

To the first group belong the typical (obligatory) parasites of cattle. Some of them, e. g. *Thelazia gulosa*, *Thelazia skrjabini* and *Oesophagostomum radiatum* are notable for their being especially specific to cattle, and were seldom noted in other hosts, while the remaining ones are common not only in cattle but in many other ruminants too.

The second group contains the specific parasite of sheep and goats: *Bunostomum trigonocephalum*, which only exceptionally occurs in cattle, and the specific parasites of *Cervidae*: *Ostertagia lyrata* and *Spiculoptera spiculoptera*, hitherto not noted in *Bovinae*.

It follows from the above review that 18 species of parasitic worms occur equally in both the bison and the domestic ruminants. Still, it is difficult to state whether the bison is the primary or the secondary host of these species. The present writer, however, is inclined to maintain that — taking into account the natural history of *Bison bonasus* (L.) — the primary parasite would have no opportunity to survive up to present times in this host. The genuine Białowieża bison, living in its natural habitat as a wild animal, ceased to exist in Poland in 1919. Instead, the present day bisons derive from animals domesticated to a certain degree as they came from zoological gardens and small enclosed reservations, i.e. from absolutely artificial surroundings. The breeding and the surroundings conditions, and especially the fodder conditions in the zoological gardens and the reservations mentioned, did doubtlessly bring about changes in the direct surroundings of the parasites (i.e. in the hosts body) and were not favorable to the primitive helminthic fauna. Instead, they facilitated the bison's coming in touch with new parasites, not met with till then, as it happened for instance in the zoological gardens inspected by Wetzels and Enigk. The above authors, who examined faeces of the bisons staying together with *Cervidae* and moufflons, confirmed invasion of *Müllerius capillaris*, a typical parasite of small ruminants, and *Strongyloides* sp. Similarly, *Bunostomum trigonocephalum* confirmed by the present author in bison fallen in the Zoological Garden in Warszawa points out to the artificial breeding conditions resulting in decreased specific immunity of *Bison bonasus* (L.) favorable to occasional parasites adaptation.

Part II. Environmental studies

An idea of the worm species parasitizing the *Bison bonasus* (L.) in Poland was obtained by means of helminthological dissections. However, the material obtained being absolutely unsystematic, it proved impossible to establish the extent of helminth invasions in bison in various breeding reservations. Environmental studies were undertaken with the aim of supplying information to fill in this gap and cast some light on the invasion conditions in the particular reservations of *Bison bonasus* (L.) The investigations were carried out during 1958 and 1959 on the territories of the following reservations: Białowieża, Borki, Niepołomice, Pszczyna and Smardzewice. Faeces of each animal from everyone of the above mentioned reservations were

examined by the following methods: that of Fülleborn (flotation), the sedimentation (decanting method) and that of Bermann. Besides, the surroundings themselves were subject to thorough analysis taking into account the following: 1. the occurrence of the parasite's intermediate hosts, 2. the degree of infestation of the enclosure territories by larvae of the gastro-intestinal nematodes, 3. invasive forms of parasites from outside the reservation bounds possibly penetrating into the latter, 4. communication between the bison of the particular reservations with the wild and domesticated animals and parasites being possibly interchanged between the latter and the bison.

The effect of environment on some invasions of parasitic worms

The faeces of all of the bisons in the reservations were examined by the three methods already mentioned on four occasions; in addition to this, faecal cultures were laid. This resulted in the establishing of eggs or larvae of the following parasites: 1. *Fasciola hepatica*, 2. *Dicrocoelium dendriticum*, 3. *Paramphistomum cervi*, 4. *Moniezia* sp., 5. *Dictyocaulus viviparus*, 6. *Cooperia* sp., 7. *Nematodirus* sp., 8. *Ostertagia* sp., 9. *Trichostrongylus* sp., 10. *Haemonchus* sp., 11. *Capillaria* sp., 12. *Trichocephalus* sp., 13. *Oesophagostomum* sp.

Thus, compared to the list of the bison parasites obtained by the methods of the helminthologic dissections, that obtained by the coproscopic methods did not reveal the genus *Bunostomum* (to say nothing of the representatives of genera *Setaria* and *Thelazia* which can not at all be revealed by the coproscopic methods). The reservation breeding conditions ought to be assumed unfavorable to *Bunostomum* invasion as this genus was established by dissection methods only in one animal in the Zoological Garden. Several authors (Kates 1943; Dinaburg 1945; Morgan, Hawkins 1955 and others) have confirmed the invasive larvae of *Bunostomum trigonocephalum* being highly sensible to the environment and their vitality being limited to 2 or 3 months even in favorable conditions. *Bunostomum trigonocephalum* larvae are particularly sensitive to temperature. According to Skrjabin et Schulz 1937 the frozen in ice larvae will die after a few minutes; also at temperature of $+4^{\circ}\text{C}$ they use to die soon, and only at temperatures above $+6^{\circ}\text{C}$ they can live for a longer period. It may be seen from the temperature data given below that the mean temperatures dominating in the Białowieża breeding reservation of bison do not deviate much from 0°C even in summer thus creating unfavorable conditions for the development of *Bunostomum trigonocephalum* larvae (Table VII). Frosts have been recorded during the whole year, with the exception of July and August with their mean minimum temperature slightly higher than 0°C (for the last five years).

The faeces of 104 bisons inhabiting the reservations of Białowieża, Niepołomice, Pszczyna, Smardzewice, Borki as well as the territory of the Białowieża forest wilderness itself were examined on four occasions during 1958 and 1959. The investigations were carried out in summer and autumn, and the results obtained have enabled the present author to establish the

T a b l e V I I
Index of minimum soil surface temperature measured in Białowieża
(minimum thermometer at 5 cm above soil surface)

Absolute minimum of temperature												
Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1954	-36.5	-37.3	-9.9	-9.8	-6.8	-0.7	+3.0	+3.5	-4.1	-6.4	-11.3	-10.4
1955	-22.9	-26.8	-27.4	-9.0	-3.9	-2.4	+5.4	+4.1	-1.8	-5.5	-17.6	-24.5
1956	-29.4	-34.4	-19.5	-7.4	-2.9	+1.5	-0.6	+1.4	-4.8	-11.0	-19.9	-19.1
1957	-21.5	-17.0	-22.4	-11.9	-6.9	-0.7	+3.0	-0.3	-3.9	-5.8	-12.3	-18.0
1958	-25.9	-29.2	-26.9	-14.0	-2.8	-0.5	+2.5	+1.9	-4.4	-3.3	-9.1	-20.5
Mean of absolute minimum of temperature												
1954	-15.0	-20.7	-3.4	-2.7	+4.8	+8.1	+9.1	+9.2	+5.4	+1.8	-1.8	-0.9
1955	-8.0	-10.4	-10.3	-2.9	+2.5	+5.0	+10.2	+7.9	+5.6	-0.3	-1.9	-6.0
1956	-6.7	-21.0	-9.7	-0.7	+1.3	+8.4	+7.9	+10.4	+2.7	+1.6	-6.8	-6.3
1957	-5.8	-2.7	-8.7	-2.5	+2.5	+6.0	+9.6	+7.8	+4.9	-0.9	-0.5	-7.1
1958	-9.4	-8.3	-9.3	-2.9	+5.5	+6.5	+8.2	+7.5	+3.5	+3.0	-0.3	-3.4

T a b l e V I I I
Results of coproscopic investigations

Name of parasite	Number of bisons			% of invasion of bisons in separate reservations					
	examined	invaded	% of invasion	Białowieża reservation	Białowieża wilderness	Niepolomice	Pszczyna	Smardzewice	Borki
Fasciola hepatica	104	56	53.8	69.6	100.0	-	72.2	75.0	-
Microcoelium dendriticum	104	1	0.9	3.0	-	-	-	-	-
Paramphistomum cervi	104	47	45.1	69.6	100.0	18.1	5.5	-	55.5
Moniezia sp.	104	3	2.8	-	-	-	16.1	-	-
Dictyocaulus viviparus	104	32	30.7	51.5	-	36.3	16.6	50.0	-
Trichostrongylidae	104	102	98.0	96.9	100.0	95.4	100.0	100.0	100.0
Capillaria sp.	104	4	3.8	3.0	-	9.0	5.5	-	-
Trichocephalus sp.	104	1	0.9	3.0	-	-	-	-	-

actual extent of the particular helminthiases. The results of the two-year investigations are shown in Table VIII.

It can be seen from the Table that: 1. Nematodes of the family *Trichostrongylidae*, 2. *Fasciola hepatica*, 3. *Paramphistomum cervi* and 4. *Dictyo-caulus viviparus* belong to the worms which most frequently parasitize bison. Consequently, particular attention was given to the helminthiases caused by these parasites.

Vermiosis gastro-intestinalis

Gastro-intestinal helminthiases of bison are being caused mainly by *Trichostrongylidae* Leiper 1912. Intestinal nematodes belonging to other families (*Trichonematidae* Witenberg 1925; *Trichocephalidae* Baird 1853; *Capillariidae* Neveu-Lemaire 1936) do seldom, or in small numbers, occur in *Bison bonasus* (L.) in Poland.

Owing to the very large invasion extent of the *Trichostrongylidae* nematodes, and to considerable complexity of the only sure method for classifying invasive larvae in faecal cultures, no attempts were made at establishing the invasion frequency of the particular genera of *Trichostrongylidae* family. Although practically the *Trichostrongylidae* invaded all of the animals (see Table VIII) yet the invasion intensity was insignificant in most cases. A sort of infra-infectional immunity seems presumably to form in the bison protecting the host against mass invasion by those parasites. This assumption is corroborated by the results of the helminthological dissections as well as by the insignificant numbers of eggs being revealed by the Fülleborn method. Consequently, gastro-intestinal helminthiases do not present a menace to the health of bison for the time being disregarding the limited area and high population density of the mentioned above animal in the enclosed reservations which could rather be considered as conditions favourable to mass invasions.

A series of analyses of grass samples after Baermann were carried out in order to get some information on the extent of infestation of the particular bison reservations by gastro-intestinal *Nematoda*. The grasses were sampled from ten different allotment in the enclosures and then put into the funnels of a Baermann apparatus. The precipitate was examined after 48 hours. Invasive larvae of the gastro-intestinal nematodes of bison were found solely in grasses sampled from the surroundings of the feeding places. Freely living nematodes and their larvae only were found in grasses sampled from the inner portions of the enclosures. This would point out to the highest density of invasive larvae of the gastro-intestinal nematodes occurring in the surroundings of the feeding places. This may be explained by those places being most frequently visited by the animals which usually stay there the whole day long in winter while in summer they use to call at the feeding places two times in a day, remaining there for a longer period after having eaten up the fodder and leaving their faeces in these parts of enclosures.

The rôle of beetles in the epizootiology of gastro-intestinal helminthiases

When grasses for analyzing were being sampled from the different parts of enclosures, it had been observed that the coprophagous beetles (particularly numerous in forest environment) very quickly disintegrated the faeces laid by the bison during the spring and the summer period. Faeces of that animal were repeatedly noticed to be almost completely taken away by the beetles within three or four days; most of the matter used to be brought into the subterranean corridors of the beetles. Faeces from shaded places were particularly quickly taken away. *Geotrupes stercorarius* L. was the most common species established by the present author in bison faeces. The mass character of its occurrence can be illustrated by the fact that in two-day faeces 78 specimens were found on one occasion. In this connection, it became necessary to investigate the part the coprophagous beetle plays in the epizootiology of the bison helminthiases. For this purpose several dozens of *Geotrupes stercorarius* specimens collected from fresh faeces were put into a glass jar and starved for three days. Next, a control section of five specimens was carried out and the intestine singled out and then inspected microscopically between two slides. The intestine was empty in all five of these cases, and as to parasites only *Gregarinidae* were confirmed. Seven most voracious specimens were picked out from several dozens of starved beetles and put onto a Syracuse watch glass in a suspension composed of 4 cc. of bison faeces + 1 cc. of invasional larvae of horse strongylids condensed in the Baermann apparatus. After checking whether all of the beetles under experiment began eating, they were transferred into a dark chamber and left alone for three hours. One specimen was then dissected; it contained 21 living invasive larvae of genera *Strongylus* and *Trichonema* in its intestine. The remaining six beetle specimens were put into Petri dishes and samples of faeces taken. The beetle faeces were then put onto watch glasses and disintegrated in a small amount of water by means of preparation needles; after this they were inspected through a binocular magnifier. Invasive larvae of *Strongylus* sp. were found in faeces of two beetles, one larva in each, and there were three larvae in another one. This experiment was repeated for two more times but now the beetles were fed bison faeces together with concentrated larvae of *Nematoda* belonging to the family *Trichostrongylidae* and *Dictyocaulus viviparus*. In this case too, living larvae were confirmed in beetle faeces.

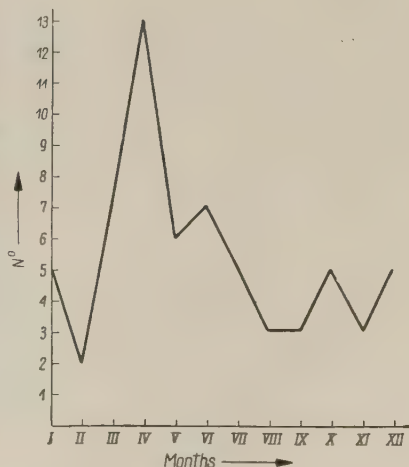
The coprophagous beetles may thus theoretically propagate the invasive larvae of *Nematoda*; yet, this seems not to play an important part practically. However, the storing of faeces in subterranean corridors, several dozens of centimeters deep, will doubtlessly result in rendering „harmless” a certain number of the nematode larvae parasitizing the bison. The nematode larvae in the bison faeces stored in the subterranean corridors of *Geotrupes* are unable of getting out onto the surface of the soil thus ceasing to play any part in epizootiology of the bison helminthiases. This presumption seems quite reasonable if the migratory properties of the invasive larvae are taken into consideration and the specific structure of the *Geotrupes* corridors as well.

Fasciolosis hepatis

There can be no doubt as to *Fasciola hepatica* belonging to the most dangerous parasites out of the 21 species confirmed by the present writer in *Bison bonasus* (L.) in Poland. As early as 100 years ago, when bison was still living free in large numbers in the Białowieża forest wilderness, attention was drawn to the periodically recurring bison mortality in spring. This was named "liver rotting" or the "Leberfäule" of the German authors. At first, the source of the disease was seen in the animals fed on *Cicuta virosa* L. abundantly growing on the marshy areas in the wilderness (Dolmatov 1848, cited by Büchner 1900; Gliński 1885). But later, the parasites were pointed at as the possible reason. Büchner 1900 had written on this subject: "...to my mind, not the grass species is noxious and causes the disease but the parasites clinging to the plants on marshy areas. These parasites, when swallowed up together with food, may sometimes cause this liver disease...". Auer 1893 — 1894 considered that the disease was caused by the *Fasciola hepatica* while Büchner 1900 presumed that it rather was *Dicrocoelium dendriticum*.

Table IX
The numbers of bisons dead because of fasciolosis in the years 1874-1892

Year Month	1874	1876	1877	1878	1879	1880	1883	1884	1885	1886	1887	1889	1891	1892	Sum
I						1					1			3	5
II														2	2
III	1							5		1					7
IV			1		1			3						8	13
V		1					1						1	3	6
VI			1			1		2	1					2	7
VII			1	2					1			1			5
VIII								2					1		3
IX		1		1							1				3
X									1	2				2	5
XI							1			1	1				3
XII										1			4		5



In analyzing in his study the reasons for bison extinction in the Białowieża forest wilderness, Auer has given detailed data on that animal's population diminution during the 1873 — 1892 period. It results from these data that from 226 bisons fallen for various reasons during that period (shot, killed by the bears, lynxes and wolves), 65 animals (40 bulis and 25 cows) died on fasciolosis hepatis.

Besides, the Auer's punctilious notes permitted to plot a graph depicting the bison mortality fluctuations. Fasciolosis hepatis had proved to cause losses

all the year round; the highest losses, however, occurred during the period of spring and summer as it may be seen in the graph and the Table IX (the data of Auer have been utilized)

During the period from 1906 to 1909, Wróblewski 1927 dissected 81 bison, shot or normally dead; he confirmed *Fasciola hepatica* invasion in 78 of them. The only three specimens in which no *Fasciola hepatica* invasion was recorded were calves which probably had no time to get invaded. The intensity of this invasion in the bison was also very considerable during this period. Suffice it to say that the author mentioned above had found 668 mature specimens parasitizing one third of the liver in one grown-up bison.

13 bison out of 81 dissected by Wróblewski died of fasciolosis hepatis. Taking into account these data, it can be assumed that practically all of the animals living in freedom were invaded by *Fasciola hepatica*.

There was not a single bison in the Białowieża forest wilderness for 10 years following World War I which had completely wiped it away. As late as 1929 first attempts were made to re-establish this species, now in enclosed reservations. Four animals purchased from Mr. J. Beyme, a breeder in Schorbow, Mecklenburg, Germany, and from Sweden represented the initial material. This re-establishment of the *Bison bonasus* (L.) had probably affected *Fasciola hepatica* invasions which became less important. The latter fact has been confirmed by the absence of any data on the losses caused by fasciolosis hepatis.

Taking into account the particular features of pathogeny of *Fasciola hepatica*, the present author gave consideration to the study of this parasite's surroundings. This study was begun with in 1958. To establish the enclosures in which the whole life cycle of the parasite can develop was the most important problem at that time. Therefore, studies of the surroundings were carried out in the reservations of Białowieża, Borki, Niepołomice, Pszczyna and Smardzewice, particular stress being put on the searching for the *Fasciola hepatica*'s intermediate host as the parasite's development in the environment depended on the presence of the latter. Alongside of this study, bison faeces from the reservations mentioned were being examined by the sedimentation methods. The search for the intermediate host of the parasite resulted in establishing large occurrence of *Galba truncatula* in Borki and Białowieża. The snail occurred in both of the two enclosures in Borki while in Białowieża large occurrence of it was confirmed in two enclosures out of the nine ones examined, and isolated stations with total area of approximately 50 square meters were found in two more enclosures. *Galba truncatula* specimens dissected in July (100 from each enclosure) were not invaded by the larval forms of *Fasciola hepatica*. The coproscopic examination results were satisfactory too: no *Fasciola hepatica* invasion was confirmed in the bison from Borki and only an insignificant ratio (10 per cent) in that from Białowieża.

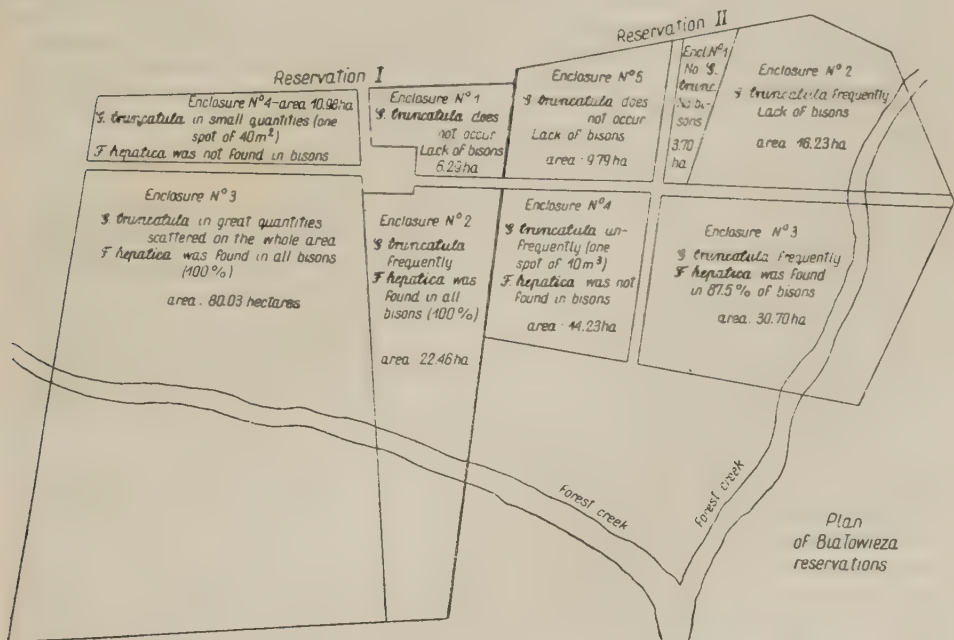
Białowieża. A particularly large occurrence of *Galba truncatula* was confirmed in the enclosures 2 and 3 of the Reservation I, and in the enclosure 3 in the Reservation II in Białowieża. Isolated eggs of *Fasciola hepatica* were found in three animals out of 30 bison examined coproscopically by the sedimentation methods in April and July. The examinations started in Białowieża were continued in April 1959; the invasion of *Fasciola hepatica* was

confirmed in 23 animals out of 30 examined. The results are shown in the sketch below.

It can be seen from the table that epizootic of *Fasciola hepatica* broke out in those enclosures where the intermediate host occurred very largely.

As *Fasciola hepatica* was established only in three animals following examinations repeated for two times in 1958, and as the *Galba truncatula* specimens dissected at the same period were free from the larval forms of the parasite, the environment could be hardly believed to become infested to such a significant extent during a few months only if no invasive forms of *Fasciola hepatica* had access to the enclosure from outside of it.

Three ways for *Fasciola hepatica* penetration could be assumed in these specific conditions: 1) hay contaminated by the parasite's metacercariae; 2) wild animals staying together with the bisons; 3) creeks flowing through the enclosures.



Scheme of the bison reservations and enclosures in Białowieża. Results of investigations carried out in 1959

The first supposition seems the less likely to occur for the same hay has been fed to all of the bison while *Fasciola hepatica* invasion has been confirmed in three enclosures only. The remaining two suppositions are, on the contrary, quite likely to be true. A creek carrying waters from the wilderness crosses the enclosures 2 and 3 in Reservation I; the same is true of the enclosures 2 and 3 in Reservation II. Taking into consideration the fact of the Białowieża forest wilderness being an area typical for *Fasciola hepatica* occurrence (which was confirmed there indeed), the metacercariae of *Fasciola*

hepatica or the infected snails may be supposed to be brought into the enclosures by the creeks during flood. Wild animals too could play their part (considerably less important, however) penetrating from the forest wilderness into the reservation through the momentarily damaged fences. So, for instance, a hind and a doe have stayed in the enclosures 2 and 3 of the Reservation I since a year.

The Białowieża forest wilderness. Bison has not occurred in freedom in the Białowieża forest wilderness following its re-establishment there after the World War I. The living conditions of the animals become quite different in character since much care is being given to the animals together with intensive feeding. As the number of the bison rose in Poland, eleven animals were let out of the reservation to live free in the Białowieża forest wilderness in 1957. There have occurred tremendous changes in the Białowieża forest wilderness since that time when Wróblewski was carrying out his studies. Yet, it retained its character favorable to *Fasciola hepatica*. This is confirmed by the extent of *Fasciola hepatica* invasions in the cattle grazing there; according to the local veterinary records as much as approximately 100 per cent of the cattle has been invaded. In 1958, the present author confirmed fasciolosis hepatis in 44.4 per cent of the bison as were let out to live in free conditions a year ago. In 1959, already 100 per cent. invasion was recorded.

Borki. The bison Reservation in Borki was started on the territory of the Borki forest wilderness in April 1956; the breeding material was taken from the Niepołomice Reservation. As the area of the Borki forest wilderness was absolutely not inhabited, the only repository of fasciolosis hepatis could be the wild animals scattered over the whole area of these tracts of woods. Hence, the small portion of wilderness — scarcely 100 hectares — allotted to the Reservation could well be supposed to be free from *Fasciola hepatica*. Neither were there any reasons to be afraid that the parasite might be introduced into the new Reservation together with the breeding material as the animals were taken from Niepołomice, a region free from *Fasciola hepatica*. The studies of the surroundings carried out in 1958 had corroborated these suppositions.

The clayey soil of this Reservation retains water and is favorable to puddle formation and this, in turn, creates the appropriate conditions for *Galba truncatula* occurring very largely on the whole Reservation area. During rainy weather, the argillaceous ground stuck to the cloven hoofs of the bison and *Galba truncatula* was thus spread along the paths beaten by the animals. 200 specimens of *Galba truncatula* were dissected in September; all of them were free from *Fasciola hepatica*.

This Reservation is free from fasciolosis hepatis disregarding the potential danger of invasion (large occurrence of *Galba truncatula*).

Niepołomice. The intermediate host of *Fasciola hepatica* does not occur in this reservation; neither were *Fasciola hepatica* invasions confirmed in the bison in the Reservation.

Pszczyna. The Reservation occupies some 500 hectares of wood tract. Most of the trees are Coniferales, mainly fir-trees. The substratum is partly wet with water remaining all year round with marshes spreading on limited

areas. A red sediment, probably ferrum compounds, was noticed on the bottom and on the plants of the water bodies and reclamation ditches examined. No *Galba truncatula* was found on the reservation area disregarding thorough searching in 1958 and 1959. On the contrary, coproscopic investigations showed a considerable ratio of *Fasciola hepatica* invasions. All the bisons of Pszczyna were lost during the years 1953 and 1954 as a result of the foot-and-mouth disease epizootic and the reservation has been renewed using breeding material from the Niepołomice Reservation, free from fasciolosis. This is to show that it was in Pszczyna itself that the invasion occurred. The fact of *Fasciola hepatica* invasion confirmed by the present author in calves born in the Pszczyna Reservation is another evidence to this effect.

The intermediate host of *Fasciola hepatica* not occurring on the reservation area as well as the absence of rivers or creeks to bring the metacercaria from beyond the reservation bounds, suggested that the invasion could have been caused by the fodder the animals were fed. Consequently, the question arose as to the origin of it. The meadows belonging to the Centre for Rare Animals Breeding in Pszczyna are situated along the river Pszczynka and are being overflowed periodically. They are wet even during drought periods, some portions of the meadows are marshy, grown with sour grasses, rush and other swamp plants. Thorough searchings resulted in finding a small number of dwarf forms of *Galba truncatula* scattered over the whole area of the meadows examined.

Domestic animals have no access to these meadows and the deer from the neighbourly woods are the only *Fasciola hepatica* final hosts grazing there. In order to establish the invasion ratio in the deer grazing on the meadows mentioned above, two roebucks were shot; in both cases *Fasciola hepatica* invasion was confirmed, although not very intensive: nine specimens of the parasite were found in one animal, and six in the other. Most of the specimens found were still young forms.

Smardzewice. The Smardzewice Reservation is situated in a dry pine forest on sand soil. Water in deepenings remains for a very short period even following heavy downpours. This is the reason why neither *Galba truncatula* nor any other water snail species occur on the reservation territory. Isolated eggs of *Fasciola hepatica* were found on seven occasions in faeces of eight bisons inhabiting this reservation; the examinations were carried out by the decantation methods.

The *Fasciola hepatica* invasion, however, ought to be made possible thanks to the hay contaminated with the parasite's metacercaria similarly as the case was in Pszczyna for the Smardzewice animals were brought from Niepołomice (a reservation free from *Fasciola hepatica*).

Fasciolosis preventing

It may be seen from the preceding study that fasciolosis hepatis has actually occurred in three breeding reservations of bisons. Although the ratio of animals infested is very high still the intensity of invasion is not yet considerable taking into consideration the good condition of the animals infested and the absence of any clinical symptoms. This good condition doubtlessly

results from the intense feeding to the animals highly nutritious fodder all the year round. Already Wróblewski paid attention to health conditions of the infested animals. He noticed that losses in bison caused by fasciolosis hepatis occurred mostly in spring, i. e. at the period when the animals living in freedom were enduring the hardest hunger and were in the worst conditions. In these cases even a relatively insignificant invasion was bringing about losses. On the contrary, the animals were in good condition disregarding *Fasciola hepatica* invasion during the summer and autumn period when there was plenty of food in the Białowieża forest wilderness. Wróblewski had expressed the opinion that the animals would overcome the invasion should they have good food during spring. Although actually the animals do not suffer hunger at any season and, quite on the contrary, are intensely fed, still the fasciolosis hepatis problem may not be neglected owing to the specific conditions of the reservation breeding of the bison. The fact of the animals being enclosed within a limited area inhabited by the already infested intermediate host is favorable to the parasites accumulating in the body of the bison. The intensity of this invasion may be supposed to increase from year to year just the same as the infestation of the surroundings will grow more and more significant. In such conditions even the good feeding of the animals can fail to protect them against clinical disease and death. Consequently, the attempts at preventing further spread of the fasciolosis seem to be indispensable in the reservations. Any attempts at therapeutic intervention must be, for the time being, given up due to the high toxicity degree of the commercial fasciolocidic drugs for cattle, and on account of the lacking data on the bison response to these drugs and, finally, because of the difficulty to administer any drugs to bison.

Thus, prophylaxis would be the only practicable measure consisting in preventing the still healthy animals from being infected and in limiting the superinvasion in those already struck by the disease. This task can be most easily attained in the Pszczyna and Smardzewice Reservations where the intermediate host of *Fasciola hepatica* does not occur, as already was stated; and where the invasion of the bison was due to the hay brought in from areas struck with *Fasciola*. It would be sufficient to change the hay in the case of those reservations.

Much worse are, however, the conditions in Białowieża with its large occurrence of the already infected *Galba truncatula*, and with creeks that cross the reservations coming from the Białowieża forest wilderness, a territory affected with *Fasciola* to an exceptional degree. A complete annihilation of the intermediate host and fencing off the creeks crossing the enclosures would be necessary in order to protect the bison against the progressing *Fasciola hepatica* invasion in that reservation. The *Galba truncatula* annihilation, however, was feasible in two enclosures only (No. 4 in Reservation I, and No. 4 in Reservation II) where the snail occurred on a limited area of some 50 sq. m. A drug non toxic to mammals had to be utilized for the *Galba truncatula* control in order to avoid any losses in the bison inhabiting those enclosures.

Taking into account the insignificant area of the *Galba truncatula* stations (some 40 sq. m. in the enclosure No. 4, Reservation I, and about 10 sq. m.

in the enclosure No. 4, Reservation II) sodium chloride in substantia was utilized. The whole surface of the two stations was covered with a sodium chloride layer several millimeters thick; 40 kg. of sodium chloride were utilized to treat the area of 50 sq. m. Subsequent observations had shown this concentration to be quite effective in controlling the snails. However the annihilation of the *Fasciola hepatica* intermediate host proved unfeasible in the already infected enclosures. This was related to the considerable spread of the snail over wide areas in those enclosures and to the specific features of the forest wilderness as well. Numerous wind fallen trees and moulding trunks scattered over the area of these enclosures make difficult moving about to say nothing of forcing one's way through this jungle with all the necessary supplying equipment.

For the same reasons the annihilation of *Galba truncatula* was given up in enclosures where there was a mass occurrence of these snails and the measures were solely limited to transferring the bisons into enclosures free from *Fasciola hepatica* and to periodical environmental examinations. The examinations were carried out in April, May, July and September 1959 in the enclosures mentioned; this permitted to trace the fluctuations in the occurrence of the intermediate host. The results were as follows: *Galba truncatula* occurred in large numbers in April, and in very large numbers in May, while isolated specimens only were being observed in July, i. e. that very month when the peak of this snail occurrence was normally observed. The present author had found only 6 living specimens of *Galba truncatula* on the area of four enclosures during two days in July while an average of 100 specimens was being found during one hour in May. This considerable fall in *Galba truncatula* occurrence is to be accounted for by the exceptionally dry summer which resulted in drying up even of the larger water bodies in the enclosures, and absolute drying up of damp portions of the area. A similar picture was revealed when the environmental examinations were being carried out in September. Living specimens of *Galba truncatula* had been observed only on two occasions then disregarding the presence of puddles in the enclosures at that period. Thus, the *Fasciola hepatica* larvae could practically reach the invasional stage in an insignificant number of *Galba truncatula* specimens only on the area of the bison reservations in 1959.

Paramphistomosis

The *Paramphistomum cervi* invasion was confirmed by the sedimentation methods in 45 per cent. of the bison specimens, the invasion extent of this parasite occupied the third place following the gastro-intestinal nematodes from the *Trichostrongylidae* family and *Fasciola hepatica*. *Paramphistomum cervi* is a particularly wide-spread parasite in Białowieża and in Borki as a result of large occurrence of its intermediate host in those reservations. The enclosures No. 2 and 3, Reservation I, and No. 2 and 3, Reservation II in Białowieża abound in puddles with prolific vegetation, and in reclamation ditches retaining water all year round. These places are inhabited by large numbers of snails from the family *Planorbidae*. There also are many *Planorbidae* in the creeks crossing these enclosures. The bisons frequently call

on water bodies inhabited by the intermediate hosts of *Paramphistomum cervi*; the animals drink from that water and contaminate it with their faeces. The conditions look very much the same in Borki with its enclosures abounding in puddles overgrown with vegetation, and inhabited by large numbers of *Planorbidae*; these puddles are the natural watering-places of the bisons. A significant rise in proportion of the infected animals may be observed in those reservations. This can be seen in the following Table giving the results for the two recent years.

	Year:	1958	1959
Białowieża, enclosed reservation		50.0%	60.0 %
Białowieża, the forest wilderness		66.6%	100.0 %
Borki		40.0%	55.5%

In the remaining reservations, the intermediate host of *Paramphistomum cervi* either does not occur at all (e. g. in Smardzewice) or does so in a very insignificant number (e. g. in Niepołomice and Pszczyna); that is why this invasion is unimportant.

Verminosis pulmonum

In Poland, verminosis pulmonum is provoked by *Dictyocaulus viviparus*. Wróblewski, however, mentioned in his study that invasion of *Dictyocaulus filaria* ("*strongilus filaria*", in Wróblewski's nomenclatory) was noted besides that of *D. viviparus* ("*strongilus micrurus*" in the original study by Wróblewski) in each *Bison bonasus* (L.) dissected. Yet, the present author's studies did not corroborate this point as only *D. viviparus* specimens were found. On one occasion, however, (the bison "Plato" from Białowieża), these markedly differed from the ordinary specimens being

Table X

Per cent of bisons invasion by *Dictyocaulus viviparus*, determined by Baermann's method

Reservation	Number of bisons			Bisons in the first year of life			Bisons in the second year of life			Bisons above two years of life		
	examined	invaded	% of invasion	examined	invaded	% of invasion	examined	invaded	% of invasion	examined	invaded	% of invasion
Białowieża	33	17	51.5	7	7	100	5	2	40.0	21	8	38.0
Niepołomice	22	8	36.3	5	5	100	3	2	66.6	14	1	7.1
Pszczyna	18	3	16.6	2	2	100	4	1	25.0	12	0	0.0
Smardzewice	8	4	50.0	0	0	0	2	2	100.0	6	2	33.3
Together	81	32	39.5	14	14	100	14	7	50.0	53	11	20.7

considerably larger in size but still preserving the structure typical of *D. viviparus*. Similarly, only this species larvae were revealed in all of the positive Baermann analyses.

The examination of the bison faeces after Baermann methods confirmed verminosis pulmonum in the following reservations: Białowieża, Niepołomice, Pszczyna and Smardzewice. This invasion was not noted neither in the bison from the Białowieża wilderness itself nor in that from Borki Reservation. The Table above shows that the *D. viviparus* invasion was the highest in the calves (100 per cent.) (Table X). Also the number of larvae revealed by the methods of Baermann was the highest in this group amounting from a few dozens to as much as 500 specimens in one analysis (35 cu. cm. of faeces were taken for the Baermann analyses). In the second-life-year bisons, isolated larvae only were found in most cases (two bisons from the Smardzewice Reservation with 180 and 60 larvae of *D. viviparus*, resp., were an exception). The intensity of expelling the larvae diminished still more in the grown-up animals. The present author's investigations on verminosis pulmonum did not cover a whole year cycle; nevertheless, the distinct differences in this invasion extent and intensity in different age groups seemed to point out to some immunity to this disease in the bisons which had already had it once, similarly as it is the case with cattle.

Dicrocoeliosis

Dicrocoelium dendriticum was confirmed by both the coproscopic methods and dissection only in the Białowieża bisons. However, the proportion of bisons infected as established by the sedimentation methods (3 per cent.) was not commensurable to the results obtained by dissection. For *D. dendriticum* was established in 75 per cent. of the Białowieża bisons dissected. This divergency in results obtained showed the coproscopic methods inaccuracy in this case.

A roebuck was let in into the No. 2 enclosure of the Białowieża Reservation I in 1958. The animal was found in a snare in the forest wilderness when a few month old kid; the animal was kept in the house of a forestry worker during the time necessary to treat his broken leg. The roebuck was shot in April 1959 as its eventual helminthologic dissection was expected to supply some information as to what degree the reservation environments were infected with the particular parasitic species in Białowieża. The roebuck was expected to be a kind of "money-box" for parasites occurring in bison owing to the practical impossibility of that animal getting in touch with the invasional forms of the parasites (especially of those with complicated life-cycle) prior to its entering the bison reservation. The results of the helminthologic dissection of the roebuck showed the animal being not only infected with the parasites ordinarily confirmed by the coproscopic methods in the bisons from that enclosure, but also invaded by *D. dendriticum* of which 33 specimens were found, one of them a young one, sexually immature. This fact is demonstrative of all links necessary for *D. dendriticum* life-cycle being present in the bison reservation in Białowieża.

The problem of parasite interchange between the bison
and the domesticated and wild animals

The bison were coming in touch with the domestic animals very frequently at the period when the former occurred as wild animals in the forest wilderness. According to Wróblewski 1927, 8342 heads of cattle were systematically grazing in the forest wilderness itself during the first decade of the 20th century, and some 3 or 4 thousands of cattle and one thousand of sheep used to be driven through the wilderness areas each year. The *Cervidae* were in a similar situation (Sztolcman 1926, Wróblewski 1927). Only the following ruminants occurred in the Białowieża forest wilderness up to 1865: the bison, the elk and the roe-deer, the red deer being already exterminated by that time. Eighteen red deers were brought into the wilderness from the Duke of Pless' estate, Silesia, in 1865. From that point on the number of red deer considerably increased reaching 230 heads by 1888. Hunting restrictions, good environmental conditions, ruthless wolf and lynx control as well as systematic importation of new specimens from Austria, Germany and from Spała, near Łódź, resulted in further increase of the deer population during the following years. Meanwhile the fallow deer was brought into the Białowieża forest wilderness. There were 5054 red deer, 1250 fallow deer and 5229 roe-deer by 1907 as a result of these measures. And by 1914, besides of the 737 bison, the wilderness was inhabited by 59 elks, 6778 red deer, 1488 fallow deer and 4966 roe-deer. Thus, approximately 21633 ruminants were inhabiting 128000 hectares of the Białowieża forest wilderness in 1914; 8342 of these animals were cattle and 13291 belonged to the *Cervidae* family. This means that there were over 169 ruminants to 1000 hectares of the wilderness by that time. Such a considerable density of hosts, with parasitic fauna common to all of them in most cases, could not but bring about a significant infestation of the bison surroundings with the larvae of parasitic worms. This excess in Białowieża wilderness population was very likely to cause the dangerous fasciolosis hepatis mentioned by Wróblewski.

At present, the bison are completely separated from the domestic animals, the possibility of their infestation with the parasites of the latter being thus eliminated.

The Białowieża forest wilderness with its large numbers of cattle grazing there represents an exception, where the cattle certainly plays an important part in the fasciolosis hepatis epizootic on the wilderness area.

The rough and the green fodder fed to the bison in the enclosed reservations originated either from the wood territories or from meadows or fields inaccessible to the domesticated animals in most cases. Consequently, there was little probability of the invasive forms of the domestic cattle worms being brought in with the fodder. But the invasional forms of the wild animal worms, on the contrary, could well be brought in with the fodder as it was the case in Pszczyna. As already stated above, the bison inhabiting this reservation were struck by *Fasciola hepatica* invasion as a result of being fed hay from moist forest meadows frequented only by the *Cervidae* (roe-deer). Besides, there was also some evidence on the pa-

rasite exchange between the wild ruminants (*Cervidae*) and the bison in the Borki forest wilderness. This reservation was arranged on an area abounding in *Cervidae*, mainly in deer. Four bisons were brought into this new reservation in 1956. The animals came from Niepołomice, a reservation completely inaccessible to wild animals. Some exchange of parasites between the *Cervidae* and the bison could possibly occur in Borki for the present author found a typical *Cervidae* parasite, *Spiculopteragia spiculoptera*, in a dissected two years old bison. This parasite was, till now, never noticed in the *Bovinae*.

In most cases, however, the bisons and the *Cervidae* came in touch with each other sporadically only when the *Cervidae* penetrated onto the reservation area through bad or momentarily damaged fences. Only in Pszczyna alone the conditions are different. This reservation occupies rich hunting grounds abounding in fallow deer, red deer and roe-deer. Old stake fences separating the reservation from the adjacent tracts of woods represent no obstacle to the unimpeded migration of the *Cervidae* onto the reservation area. Approximately thirty fallow deers, and about a dozen or more of red deer and roe-deer are estimated to make up the number of wild ruminants in the reservation. The fallow deer remain on the reservation area the whole year round, and they may often be seen (from a few to several dozens at a time) grazing on the forest meadows, frequently simultaneously with the bisons. The red deer use to go over into neighbouring forest tracts during their oestral period; however, even then individual animals remain within the bounds of the reservation. The roe-deer less frequently leave the reservation. Thus, the deer, remaining on the same territories with the bisons, certainly play some part in infestation of the bison environment by the invasive larvae of the parasites. In order to get some idea on the parasitic species invading the *Cervidae*, and on the intensity of invasion, a complete helminthologic dissection of four roe-bucks was carried out; the animals had been shot in the nearest vicinity of the bison reservation. Besides, the dissection of a deer stag from the reservation itself was performed too. As a result, the following non-specific parasites were confirmed in the animals dissected: *Haemonchus contortus* (in all of the animals), *Fasciola hepatica* (in 3 roe-deers), *Dictyocaulus viviparus* (in 2 roe-deers), *Paramphistomum cervi* (in one deer stag) and *Trichocephalus ovis* (in one roe-buck). *Haemonchus contortus* occurred most frequently, its invasion bearing a mass character: up to 712 specimens in one roe-buck.

Conclusions

(1) 25 specimens of *Bison bonasus* (L.) fallen for different reasons were examined by the methods of the complete helminthologic dissection; in 23 cases invasions of parasitic worms were confirmed.

(2) 21 species of parasitic worms were established in the material dissected, including 3 species of *Trematoda*, 2 species of *Cestoda* and 16 species of *Nematoda*.

(3) For the first time in Poland, four species of parasitic *Nematoda* were

established: *Thelazia gulosa*, *Thelazia skrjabini*, *Spiculoptera spiculoptera* and *Capillaria bilobata*.

(4) *Bison bonasus* (L.) turned out to a new host for six species of worms: *Moniezia* sp., *Ostertagia lyrata*, *Cooperia mcmasteri*, *Spiculoptera spiculoptera*, *Thelazia gulosa* and *Thelazia skrjabini*.

(5) Four species were confirmed to be synonymous of species previously described. Thus, *Ostertagia gracilis* Koffmann 1942 is synonymous of *Cooperia oncophora* (Railliet 1898) Ransom 1907; *Dictyocaulus bisonis* Koffmann 1942 is synonymous of *Dictyocaulus viviparus* (Bloch 1782); *Capillaria bisonis* Koffmann 1942 is synonymous of *Capillaria bilobata* Bhalerao 1933; *Capillaria megrelica* Rodonaja 1947 is synonymous of *Capillaria bilobata* Bhalerao 1933.

(6) Out of the 21 worm species confirmed in the bison in Poland, 19 belong to the typical parasites of the domestic ruminants; one species (*Spiculoptera spiculoptera*) has been considered as specific parasite of *Cervidae* and has, up to now, been never noted in *Bovinae*. As regards the last parasite, *Moniezia* sp., it was impossible to determine its species owing to the insufficiency of the material available (one not complete specimen).

(7) The extent of the parasitic invasions in the bison showed impossible to establish for each of the particular breeding reservations because of the absolutely accidental nature of the material dissected, taken from animals fallen of different diseases. For, the causes of the animals' death were presumed to have influenced the helminthologic picture. Consequently, coproscopic examinations and environmental studies were undertaken in order to cast light onto the invasion relationships in the particular breeding reservations of the bison.

(8) By means of examinations of faeces sampled from 104 bisons (Fülleborn, sedimentation, and Baermann methods were applied) repeated for four times, it was established that the following worms belong to the most frequent parasites occurring in the bison in Poland: *Nematoda* from the family of *Trichostrongylidae* — 98 per cent. occurrence, *Fasciola hepatica* — 54 per cent., *Paramphistomum cervi* — 45 per cent., *Dictyocaulus viviparus* — 31 per cent.

(9) The list of the coproscopically established parasites as compared with that of parasites established by means of the dissection contains one species less than the former one, namely: *Bunostomum trigonocephalum* which was established by the latter methods only in the bison inhabiting zoological gardens. The reservation breeding conditions have been supposed unfavorable to this invasion. This supposition has been corroborated by the analysis of temperature conditions in the Białowieża Reservation.

(10) The insignificant number of eggs of the gastro-intestinal nematodes established by the Fülleborn methods proved the intensity of these helminthiasis insignificant in *Bison bonasus* (L.) A kind of intra-infectious immunity seems likely to form in the bison.

(11) Contamination of the enclosures areas with the gastro-intestinal nematode larvae was neither important. The results of the Baermann analyses showed the invasive larvae of gastro-intestinal *Nematoda* being present solely in grass samples taken from the feeding places.

(12) Faeces laid by the bisons during the spring and summer period use to be very quickly taken away by the coprophagous beetles, particularly numerous in the sylvan surroundings of the reservation.

(13) Experimental studies on the capacity of the invasive larvae of *Nematoda* to survive in the intestine of the most frequently noted beetle species, *Geotrupes stercorarius*, showed the larvae eaten up by the beetles to remain vital and to be then expelled with faeces.

(14) Taking into account the coprophagous beetle biology, the part they play in the epizootiology of the bison helminthiases in reservation conditions seemed to be favourable.

(15) It results from the review of the literature that *Fasciola hepatica* occurring in 53.8 per cent. of the bisons in Poland is the parasite most dangerous to that animal.

(16) The intermediate host of *Fasciola hepatica*, *Galba truncatula*, occurs both in Białowieża and in Borki.

(17) The bringing of the invasive forms of *F. hepatica* onto the area of the enclosures from outside the reservation was confirmed to be possible. Thus, the larval forms of *F. hepatica* were brought into three enclosures by the creeks flowing from the wilderness, in Białowieża. As to the *F. hepatica* invasion in Pszczyna and Smardzewice, the feeding to the bisons of hay containing metacercariae of the parasite accounts for this fact to the present author's mind.

(18) *Paramphistomum cervi* invasion was confirmed in 45 per cent. of the bisons examined. The parasite was noted to occur most frequently in the Białowieża forest wilderness (100 per cent.); it was found less frequently in the enclosed Białowieża reservation (69.6 per cent.) and in Borki (55.5 per cent.).

(19) In Poland, the pulmonary helminthiasis is caused by *Dictyocaulus viviparus*. A certain immunity develops in the bisons after having had this disease, similarly as it is the case in cattle.

(20) *Dicrocoelium dendriticum* was confirmed solely in the Białowieża bisons. The observations carried out showed all the links necessary for *D. dendriticum* life-cycle to be present in the reservation.

(21) The bisons' getting in touch with the domestic animals occurred only on the territory of the Białowieża forest wilderness.

(22) The bisons' getting in touch with the *Cervidae* was casual in most reservations, the only exception being Pszczyna where some thirty fallow deers and a dozen of red and roe-deer were living together with the bisons.

(23) Several facts point out to an existing interchange of parasites between the *Cervidae* and the *Bison bonasus* (L.).

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STRESZCZENIE

Autor zbadał 25 żubrów padłych z różnych przyczyn, stwierdzając w 23 przypadkach inwazję robaków pasożytniczych. W materiale sekcyjnym wykryto ich 21 gatunków, w tym 3 gatunki przywr, 2 gatunki tasiemców i 16 gatunków nicieni — p. tabela I.

Cztery gatunki nicieni zostały stwierdzone w Polsce po raz pierwszy; są to *Thelazia gulosa*, *Thelazia skrjabini*, *Spiculoptera spiculoptera* i *Capillaria bilobata*. Dla sześciu gatunków: *Moniezia* sp., *Ostertagia lyrata*, *Cooperia mcmasteri*, *Spiculoptera spiculoptera*, *Thelazia gulosa* i *Thelazia skrjabini*, żubr okazał się nowym żywicielem.

Cztery gatunki zostały uznane za synonimy gatunków wcześniej opisanych. I tak *Ostertagia gracilis* Koffman 1942 jest synonimem *Cooperia oncophora* (Railliet 1898) Ransom 1907; *Dictyocaulus bisonis* Koffman 1942 jest synonimem *Dictyocaulus viviparus* (Bloch 1782); *Capillaria bisonis* Koffman 1942 jest synonimem *Capillaria bilobata* Bhalerao 1933, a *Capillaria megrelia* Rodonaja 1947 uznana została również za synonim *Capillaria bilobata* Bhalerao 1933.

Z 21 gatunków robaków stwierdzonych u żubra w Polsce, 19 należy do typowych pasożytów domowych przeżuwaczy, jeden gatunek (*Spiculoptera spiculoptera*) uważany jest za specyficznego pasożyta jeleniowatych i do tychczas u *Bovinae* nie był notowany.

Dość przypadkowy materiał sekcyjny, pochodzący z żubrów padłych na różne schorzenia, nie pozwalał na ustalenie intensywności inwazji pasożytniczych u żubrów w poszczególnych rezerwatach hodowlanych. W związku z tym podjęto badania koproskopowe i środowiskowe, mające wyjaśnić aktualne stosunki inwazyjne w poszczególnych rezerwatach i zagrodach. Badając 104 żubrów ustalono, że do najczęstszych pasożytów żubra w Polsce należy zaliczyć: nicienie z rodziny *Trichostrongylidae* — 98%, *Fasciola hepatica* — 53,8%, *Paramphistomum cervi* — 45,1% i *Dictyocaulus viviparus* — 30,7%.

Niewielka liczba jaj nicieni żołądkowo-jelitowych wykrywana w kale i nieznaczne zarażenie zagród ich larwami wskazują, że intensywność tych robaczyc u żubrów jest niewielka. Wydaje się, że na zmniejszenie rozprzestrzenienia robaczyc żołądkowo-jelitowych żubra wpływać może działalność żuków kałozernych, w pierwszym rzędzie z rodzaju *Geotrupes*, rozpraszających i zagrzebujących kał wraz z jajami i larwami inwazyjnymi nicieni.

Najgroźniejszym pasożytem żubra jest *Fasciola hepatica*, występująca w Polsce u 53,8% żubrów. Jej żywiciel pośredni, *Galba truncatula* występuje w rezerwatach w Białowieży i w Borkach. Stwierdzono również możliwość zawlekania na teren zagród żubrzych inwazyjnych postaci *F. hepatica* spoza rezerwatów: przez strumienie puszczańskie w Białowieży lub wraz z sianem w Pszczynie i Smardzewicach.

Inwazję *Paramphistomum cervi* stwierdzono u 45,1% badanych żubrów. Najczęściej pasożyt ten występuje w Puszczy Białowieskiej — 100%, rezerwacie zamkniętym w Białowieży — 69,6% i w Borkach — 55,5%.

Robaczyca płucna żubrów wywoływana jest przez *Dictyocaulus viviparus*. Podobnie jak u bydła, obserwuje się istnienie pewnej odporności po przebyciu robaczycy płucnej.

Dicrocoelium dendriticum stwierdzono tylko u żubrów w Białowieży. Przeprowadzone badania wykazały, że w rezerwacie tym istnieją wszystkie ogniwa cyklu rozwojowego *D. dendriticum*.

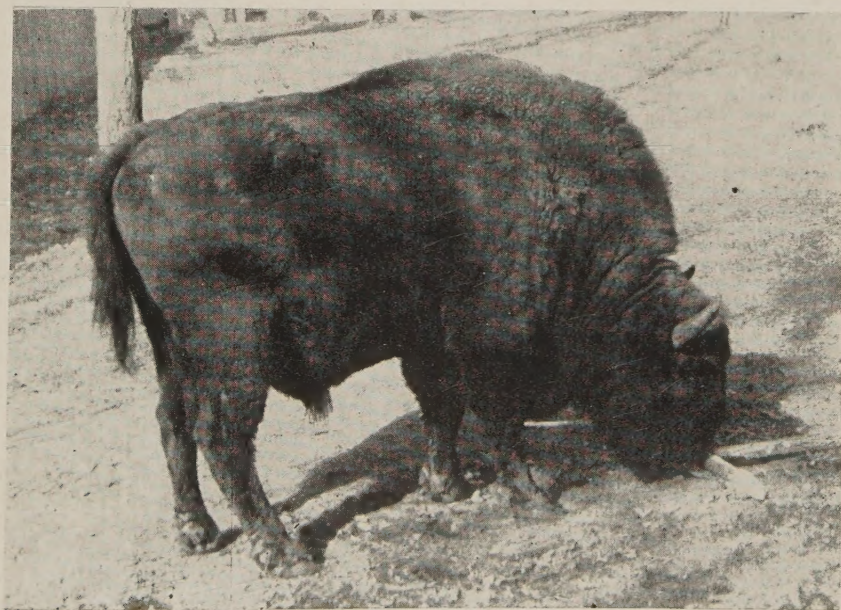
Kontakty żubrów ze zwierzętami domowymi mają miejsce tylko na terenie Puszczy Białowieskiej. Kontakty żubrów z jeleniowatymi są w większości rezerwatów sporadyczne; wyjątek stanowi Pszczyna, gdzie razem z żubrami przebywa około 30 danieli, kilkanaście jeleni i sarn. Szereg faktów wskazuje na istnienie wymiany pasożytów między jeleniowatymi a żubrem.

EXPLANATION OF PLATES I-IV

- Phot. 1 a. 2 — Białowieża bisons, bulls, in good condition disregarding fasciolosis (without any clinical symptoms).
- Phot. 3 a. 4 — Bisons in the Białowieża Reservation.
- Phot. 5 — A characteristic marshy scenery in the Białowieża Reservation; typical biotop of *Galba truncatula*.
- Phot. 6 — A forest creek flowing through the Bison Reservation in Białowieża. Its waters bring the invasive forms of *F. hepatica* into the enclosures.
- Phot. 7 — One of the numerous puddles, habitat of the intermediate hosts of *P. cervi* in the Białowieża Reservation
- Phot. 8 — Smardzewice Reservation with dry sandy soil. Lack of *Galba truncatula* or any other aquatic snail.



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